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AN

ESSAY

ON THE

Variation of the Compass,

SHEWING

HOW FAR IT IS INFLUENCED BY A CHANGE IN THE
DIRECTION OF THE SHIP'S HEAD,

WITH

AN EXPOSITION OF THE DANGERS ARISING TO
NAVIGATORS FROM NOT ALLOWING FOR
THIS CHANGE OF VARIATION.

INTERSPERSED WITH
PRACTICAL OBSERVATIONS AND REMARKS.

BY

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1817.

THECA·BOD

TO

JOHN WILSON CROKER, Esq. M. P.

LL. D. F. R. S.

WHOSE ABILITY IN TRANSACTING

THE COMPLICATED AND IMPORTANT DUTIES OF

Secretary of the Admiralty,

AND WHOSE ZEAL FOR THE IMPROVEMENT OF

NAVIGATION,

HAVE SECURED HIM THE ESTEEM OF ALL NAUTICAL MEN,

AND THE APPROBATION OF THE COUNTRY AT LARGE,

THIS LITTLE WORK IS MOST RESPECTFULLY INSCRIBED,

BY

HIS MUCH OBLIGED,

AND MOST OBEDIENT HUMBLE SERVANT,

THE AUTHOR.

ADVERTISEMENT.

My chief object in publishing the following Essay, has been to call the attention of NAUTICAL MEN *to the consideration of the change in the variation of the compass, caused by a change in the position of the ship's head. The non-attendance to this change in the variation has, I am fully convinced, occasioned much loss, and many fatal accidents: And if this Work shall in any way be instrumental in putting Navigators on their guard against such misfortunes in future, it will have completely attained its object.*

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My chief object in publishing the following Essay, has been to call the attention of NAUTICAL MEN *to the consideration of the change in the variation of the compass, caused by a change in the position of the ship's head. The non-attendance to this change in the variation has, I am fully convinced, occasioned much loss, and many fatal accidents: And if this Work shall in any way be instrumental in putting Navigators on their guard against such misfortunes in future, it will have completely attained its object.*

CONTENTS.

Page.

SECT. I. Changes of Variation 1

II. Direction of the Curves of no Variation.—Changes of their Direction 20

III. Inquiry concerning the Dip of the Magnetic Needle—Tables of Dip in various Latitudes . 36

IV. Observations establishing a Change of the Variation, consequent on a Change in the Position of the Ship's Head relatively to the Meridian—Fatal Effects of not adverting to this Change in determining the Ship's Place, exemplified in various instances 52

V. Captain Flinders' Rule for ascertaining the amount of the Changes in the Variation—Remarks on that Rule—Miscellaneous Observations . . . 113

AN

ESSAY

ON THE

VARIATION OF THE COMPASS.

SECTION FIRST.

Changes of Variation.

MANY years elapsed after the discovery of the compass, before it was thoroughly ascertained that the needle did not exactly indicate the true poles of the world; and it was not till the middle of the sixteenth century, that observations made in England and France clearly demonstrated this variation.

At London, in 1580, the quantity of variation was found to be 11° 15′ east; in 1622, 6° east; in 1634, 4° 5′ east; and in 1657, the needle coincided with the true poles of the world; so that a period of 87 years elapsed in changing the 11° 15′ of easterly variation in that city to zero, or until the variation began to take a westerly direction.

In 1672, the variation was 2° 30′ west; in 1723, 14° 17′ west; in 1747, 17° 40′ west; in 1780, 22° 41′ west; and in 1793, (or 136 years afterwards,) the variation was nearly 24½° west.[1]

At Paris, in 1550, the variation was 8° east; and in 1660, the needle pointed to the true poles of the world. In 1681, the variation was 2° 2′ west; in 1760, 18° 20′ west; and in 1804, 22° 20′ west. Hence it follows, that whilst the variation was undergoing an annual change of 10′ 4″ during a period of 213 years at London, the yearly change at Paris during a term of 254 years, was only 7′ 10″.[2]

At Dublin, in 1657, the needle coincided with the true poles of the world. In 1791, the variation was 27° 23′ west; exceeding the variation observed in London 3° or 4°; and consequently the annual change, which was uniform, during 134 years, must have been about 12′ 10″.[3]

Whilst the variation was undergoing this change at London, Paris, and Dublin, we find an almost corresponding change at Cape Agulhas and the Cape of Good Hope. At the former of these places there was no variation in 1600; and in 1692, it amounted to 11° west. At the Cape of Good Hope in 1700, the variation was nearly

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[1] Hutton's Math. and Philos. Dict. 1st edit. vol. ii. p. 634.

[2] Ib. vol. ii. p. 638.

[3] Ib. vol. ii. p. 638.

10° west;[1] and in 1791, it had increased to 24° 31′ 52″ west:[2] so that, during a period of 91 years, the annual change in the variation at the Cape of Good Hope, must have been about 9′ 15″.

At St Helena, the variation in 1600 was 8° east; in 1628, 6° east; in 1677, 0° 40′ east; in 1692, 1° west; in 1776, 13° 15′ west; and in 1794, it was found to be 16° 16′ west:[3] consequently, the mean annual change in the variation at this place, during a period of 194 years, has been at the rate of 7′ 52″.

At Cape Comorin in 1620, the variation was 14° 20′ west; in 1688, 7° 30;[4] in 1756, one quarter of a degree;[5] and in 1816, there was still no variation at this place:[6] therefore, during a period of 137 years, the annual change was 6′ 17″; but during a space of 59 years, that is, from 1757 to 1816, the variation has been *stationary*.

The phenomena presented by the variation at Cape Horn and its vicinity, are extremely different from those observed at the Cape of Good Hope, Paris, and London.

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[1] Philos. Trans. for the year 1757.

[2] D'Entrecasteaux's Voyage in Search of La Perouse.

[3] Bouditch, Epitome of Navigation, p. 149.

[4] Hutton's Math. and Philos. Dict.

[5] Philos. Trans. for the year 1757.

[6] Biot, Traité de Physique.

In 1683, in Lat. 57° 27′ south, Long. 57° 28′ west, the variation was found to be 23° 10′ east.[1] In 1775, in Lat. 56° 27′ south, Long. 54° west, 24° 30′ east variation was found.[2] In 1786, in Lat. 53° south, Long. 70½° west, 22° 47′ east variation was observed.[3] And in 1795, in Lat. 57° south, Long. 67° west, the variation was exactly 23° east.[4] Hence it follows, that during a period of 112 years, the variation near Cape Horn has neither increased nor diminished in a perceptible manner.

At Cambridge (Massachusetts) in 1708, the variation was found to be 9° west, and since that period it has been diminishing at the rate of 1¾′ annually;[5] whilst at Jamaica, Barbadoes, and Lima, the variation has undergone *no* change during a term of 140 years.[6] In the northern hemisphere, in the parallel of Spitzbergen, Davis' Straits, Hudson's Bay, &c. the same quantity of variation appears to have existed during a space of 150 years.[7]

The quantity of variation from Cape Comorin eastward towards the Nicobar islands, Java, Ceram, Amboyna, Timor, &c. is so very small as seldom to induce navigators to advert to it in their calculations; and is subject to little or no change. It may, however, be worthy of remark, that sixty miles east from the coast of Coromandel, about the meridian of Madras, the variation changes its denomination from east to west.

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[1] Dampier's Voyage, vol. i. p. 80.

[2] Wales' Astro. Tables to Cook's Voyage, p. 384.

[3] La Perouse, Voyage round the World, vol. ii. p. 292.

[4] Vancouver's Voyage round the World.

[5] Bouditch, Epitome of Navigation, p. 150.

[6] Humboldt, P. N. vol. ii. p. 118.

[7] Phipps' Voy. towards the North Pole. Philos. Trans. for 1757.

The same local changes probably take place on the coasts of Chili, Peru, and Mexico. In 1704, from Valparizo to Acapulco, a distance of 50° of latitude, the variation was very inconsiderable. From the former of these places to Lima it never exceeded 8° east; from Lima to the latter, never more than 4° west.[1]

The greatest variation I am acquainted with, has been observed between Cape Farewell and Labrador, in Hudson's Straits, and Baffin's Bay. In Lat. 52° north, Long. 52° west, I observed the quantity of 42° 10′ 53″ westerly variation;[2] and as high as Lat. 60° north, about the same parallel of Long. I found from 50° to 52°. I am, however, inclined to think this excess of variation must have been partially produced by the effects of local attraction.

In 1616, in Lat. 78° north, Long. 80° west,

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[1] Dampier's Voyage, vol. iv. p. 146.

[2] Sybille's Tables of Variation.

(Baffin's Bay,) 57° westerly variation was found.[1] In 1757, in Lat. 62° north, Long. 65° west, 41° west variation was observed; and in the same year, in Lat. 68° north, Long. 79° west, 48° west variation was also found.[2] In all these high latitudes, the variation still continues nearly the same.

On the west side of America, in the same parallel of latitude as Davis' Straits, Cape Farewell, &c. we perceive the variation assuming another character, and seldom exceeding half the quantity found at the above mentioned places.

In 1786, in Lat. 53° north, Long. 145° 20′ west from Paris, the variation was from 23° to 24° east. In the same year, in Lat. 58½° north, Long. 138° west, it was 25° east; and in Port des Francois, in Lat. 58° 37′ north, Long. 137° 30′ west, the variation, as ascertained by the *meridian line*, amounted to 27° east.[3] In 1793, in Lat. 53° north, Long. 231° east (129° west), the variation was only 20° 41′ east. In 1794, in Lat. 61° 17′ north, Long. 210° 53′ east, 29° 30′ of easterly variation was found; the *greatest* quantity Vancouver observed whilst on that coast.[4]

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[1] Hutton's Math. and Philos. Dict. vol. ii. p. 636.

[2] Philos. Trans. for 1757.

[3] La Perouse, vol. ii. p. 282.

[4] Vancouver's Voyage round the World.

But of all the places on the globe with which we are acquainted, none exhibit such wonderful phenomena in the variation as the coasts of China, Corea, Tartary, Japan, and Kamtschatka northward.

In 1787, from Macao to Lat. 41° north, Long. 136° east from Paris, the quantity of westerly variation never exceeded 2°; and from this last point to Lat. 51½° north, Long. 142½° east, where the variation was only 0° 53′ east, the quantity never exceeded 3°.[1]

In 1804, in Lat. 52° north, Long. 143° east from Paris, there was no variation; 16° farther to the east, and 4° to the south, 5° 20′ of westerly variation was observed;[2] and in 1779, in Lat. 69° 55′ north, Long. 195° 14′ east, (Bhering's Straits,) 35° 37′ east variation was found.[3]

From observations made between 1700, and 1775, there appeared three places or points on the globe, where the change in the variation was much *greater* than elsewhere. These were, *first*, in the middle of the Indian ocean, from 10° to 15° South Lat. and from 64° to 69° East Long. where the change was 11° and 11° 45′; *second*, in the Ethiopian sea, from 5° North to 20° or 25°

La Perouse.

[2] Krusenstern's Voyage of Discovery.

Cook's Third Voyage, vol. ii. p. 519.

South Lat. and from 10° to 15° or 20° East Long. the change in the variation was about 10°; and, *third*, at 50° North Lat. and between 17° East and 10° West Long. the change was nearly 11°. In these different places the variation has since continued to increase at nearly the same rate.

During the same interval, it was also ascertained that there were *four* places or points on the globe where the variation has undergone no change. These were, *first*, from the eastern point of Africa to the farthest of the Bermuda islands; *second*, the environs of the isle of Madagascar, and part of Zanguebar; *third*, that part of the ocean which is to the south and south-east of the Sunda islands, between them and New Holland; and, *fourth*, in the same sea, about 4° South Lat. and 97° East Long. that is, in the middle of the space comprised between the western angle of New Holland and the southern point of Africa. In all these places the variation did not vary perceptibly during 56 years.[1] And it may be remarked, that investigations made since the above period, have not shewn any change worthy of notice in its quantity at the above-mentioned places.

Some intelligent sea officers are of opinion, that, in the western parts of the English Channel, the westerly variation has begun to decline; whilst others assert, that the variation is still increasing in the Channel, and as far westward as 15° West Long. in 51° North Lat.; at which place they say the variation amounts to 30° west. Neither of those opinions, however, can be relied on as correct, though each may have been deduced from observation. If the head of the ship is on the *east* point of the compass at the time of observation, from 20° to 23° of variation will be observed; but, on the other hand, if the ship's head is at *west* at the time of observation, the observed variation will amount to 30° or 33°.[1]

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[1] Hauy's Nat. Phil. vol. ii. p. 108, 109.

In September 1814, I determined the exact quantity of the variation at the Scilly Islands. The Sybille having continued two days at St Mary's, during that interval I went with an azimuth compass, artificial horizon, and sextant, to St Agnes light-house, and there took *twelve* observations, the mean result of which gave 27° 16′ west variation. In the evening I went, with the same instruments, to St Mary's Castle, and there ascertained the variation, by an excellent amplitude, to be 27° 31′ west.[2]

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[1] See Section IV.

[2] Sybille's Table of Variation.

That the annual changes of variation might be seen in a clearer and more conspicuous point of view, I have here inserted the greater part of Dodson's Table of variations in different latitudes as given in the Philosophical Transactions for 1757, and I have added some good observations made at subsequent periods.

Should this Essay be honoured with the notice of navigators, whose course may happen to coincide with the latitudes and longitudes therein mentioned, they may, by comparing their own observations with those in the Table, at once ascertain the change the variation has undergone during given intervals of time; and if this were carefully attended to by experienced navigators, an ample series of observations would soon be procured; and it is highly probable, that much of the obscurity presently involving the variation would speedily be dispelled.[1]

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[1] It appears that the magnetic needle is more or less affected by heat and cold. In 1722–3, Mr Graham found a variation of some minutes at different hours of the same day, discoverable only by nice observations. He professed himself altogether ignorant of the cause of this phenomenon.

In 1750, Mr Wargentin, secretary of the Swedish Academy of Sciences, took notice both of the regular diurnal variation of the needle, and also of its being disturbed at the time of an aurora borealis. (*Phil. Trans.* vol. xlvii. p. 126: Hutton's *Math. and Phil. Dict.* vol. ii.) In 1756, Mr Canton commenced a series of observations, amounting to near 4000, with an excellent variation compass of about nine inches diameter. The number of days in which his observations were made was 603, and the diurnal variation of 574 of them was so regular, that the absolute variation of the needle westward increased from about 8 or 9 o'clock in the morning till about one or two in the afternoon, when it became stationary for some time; after that, the absolute variation westward decreased, and the needle returned to its former station, or nearly so, in the night, or by next morning. Hutton's *Math. and Phil. Dict.* vol. ii. p. 639.

A Table, *exhibiting the Changes in the Variation from the Year* 1700, *in the more frequented Seas.*

Lat.	Long.	Year.	Var.	Year.	Var.	Year.	Var.
50°N.	5°W.	1700	7½°W.	1756	19¼ W.	1814	27½°W.
50	10		7¾		19½		
50	15		8½		20		
50	20		9		20		
50	25		9¾		20		
45	5		6		16½	1776	25
45	10		6¼		16¼		22¾
45	15		6¾		16		
45	20		7		16		
45	25		7½		15¾		
45	30		8		15¼		
45	35		8¾		15		
45	40		9½		15½		
45	45		10½		16		
45	50		11½		17		
45	55		12½		18	1813	23½
45	60		13¾		18½		20½
40	10		5		15½	1791	26½
40	20		5¼		13½	1775	18¾
40	30		5½		11¼		
40	40		5¾		10	1813	19
40	50		6		9½		
40	60		6¼		11		
40	70		7		12¾		
35	10		4¼		14¼	1800	18½
35	20		4		13		
35	30		3¾		10½		
35	40		3¾		7¼	1775	10
35	50		3½		5½		
35	60		3¼		5¼		
35	70		2½		6¾		
30	10		3½		13¾		
30	15		3¼		12	1791	16½
30	25		2¾		9		
30	35		2¼		7		
30	40		1¾		5½	1775	8

Table continued.

Lat.	Long.	Year.	Var.	Year.	Var.	Year.	Var.
30° N.	50° W.	1700	0¾° W.	1757	3° W.		
30	60		0¼ E.		2¼		
30	70		1½		1¼		
30	80		2¼		0		
25	20		2		10½	1800	15° W.
25	30		1¼		7¼		
25	40		0½		3¾	1775	6
25	50		0¾		1		
25	60		2 E.		1¼ E.		
25	70		3½		2¾		
25	80		4¾		3		
25	60 E.		12¾ W.		6 W.		
25	70		10½		2¾		
20	25 W.		1½		8	1800	11
20	35		0¼ E.		4		
20	45		1½		0¾		
20	55		2¾		2 E.		
20	65		4¾		4		
20	75		6¾		5¼		
20	60 E.		12¾ W.		6 W.		
20	70		9¾		2¾		
20	90		3¾		1 E.		
15	20 W.		1½		9 W.	1772	11
15	25		0¼ E.		6½	1800	9¾
15	35		1½		3½		
15	45		2¼		1 E.		
15	55		4		3¾		
15	60		5		5		
15	70		6		7		
15	80		7¾		8		
15	50 E.		15¼ W.		9¾		
15	55		14½		7¾		
15	60		11½		6		
15	65		9¾		4½		
15	70		8		2¾		
15	80		5¾		0		
15	85		4¾		0¾ E.		
15	90		3¼		0½		
15	95		2½ W.		0½ W.		
10	15 W.		1¼		10		
10	20		0½		8	1772	9
10	25		0¼ E.		5½	1800	7½
10	30		1		3		

Table continued.

Lat.	Long.	Year.	Var.	Year.	Var.	Year.	Var.
10° N.	35°W.	1700	1½° E.	1756	1° E.		
10	45		3½		2½		
10	55		5		5½		
10	60		6½		6¾		
10	50 E.		16 W.		10½ W.		
10	55		15		8		
10	60		13½		6		
10	65		12		4½		
10	70		10		3		
10	75		8		1 E.		
10	80		5¼		0¼		
10	90		3½		0½		
10	95		2½		0½ W.		
5	0		4¾		15¼		
5	10 W.		1¾		11¼	1772	13½°W.
5	20		0		7¼	1776	10⅓
5	25		1 E.		4½	1800	9
5	35		2½		0½ E		
5	45		4½		4		
5	55		6½		6½		
5	5 E.		6¼ W.		16½ W.		
5	10		7¼		17½		
5	45		16¾		13¼		
5	50		16½		11		
5	55		15½		8¼		
5	60		14½		6		
5	65		12¾		4½		
5	70		10¾		2¾		
5	75		8¾		0¾		
5	80		6½		0¼ E.		
5	85		4¾		1¼		
5	90		3¼		0½		
5	95		2¼		11½ W.		
0	0		4½		15½		
0	5 W.		2¾		13¼		
0	10		1½		11	1772	14¼
0	15		0½		9		
0	20		0¾ E.		6½		
0	25		1½		4		
0	30		2½		0½	1800	5½
0	35		3¼		1½ E.		
0	40		4¼		3½		
0	45		5½		5		

Table continued.

Lat.	Long.	Year.	Var.	Year.	Var.	Year.	Var.
0° N.	100° W.	1700	6¾° E.	1756	6½° E.		
0	5 E.		6 W.		16½ W.		
0	10		7¾		17¼		
0	40		16¾		16¾		
0	45		17¾		14½		
0	50		17½		11¾		
0	55		16¼		8¾		
0	60		15¼		6		
0	65		13½		4½		
0	70		11½		3¼		
0	75		9¾		1		
0	80		7¾		0¼ E.		
0	85		5½		1¼		
0	90		4¼		1	1780	0½° E.
0	95		3¼		0½ W.		
0	100		2½		1	1772	12½ W.
5 S.	5 W.		2½		13¼		12¼
5	10		1		10¾		
5	15		0		8½	1775	6
5	20		1¼ E.		6	1800	4½
5	25		2¼		3		
5	30		3¼		0		
5	35		4½		2¾ E.		
5	5 E.		6 W.		16 W.		
5	10		7¼		17		
5	40		18		17		
5	45		18½		16		
5	50		18½		12½		
5	55		17½		9¼		
5	60		16½		6½		
5	65		14¾		4½		
5	70		13		3		
5	75		11		1		
5	80		9		0		
5	85		7		0¼ E.		
5	90		5		0¼		
5	95		3¾		0½ W.		
5	100		3		1½		
10	5 W.		2¼		14¼		
10	10		0¾		12¾	1755	11¼
10	15		0½ E.		10¼		
10	20		1¾		7¼	1772	9¾
10	25		3		2		

Table continued.

Lat.	Long.	Year.	Var.	Year.	Var.	Year.	Var.
10° S.	30° W.	1700	4° E.	1756	1° E.	1791	8¾° W.
10	35		5½		3½	1800	2 W.
10	5 E.		5¾ W.		15¾ W.		
10	10		7½		16¾		
10	15		9¼		17¾		
10	40		18¾		19¼		
10	45		19½		18		
10	50		18½		14¼		
10	55		17		10½		
10	60		15¾		7¼		
10	65		14½		5		
10	70		12½		3½		
10	75		10½		2		
10	80		8½		1		
10	85		6¾		0¼		
10	90		5		0¼		
10	95		3¾		1		
10	100		2¾		2		
10	105		2		2¾		
10	110		1		3¼		
15	0		3½ W.		14		
15	5 W.		1¾		12	1775	12¼
15	10		0¼		9½		
15	15		1¼ E.		7		
15	20		2½		5	1772	4¼
15	25		3¾		1		
15	30		5		2 E.	1791	9
15	35		6½		4½	1800	0¾
15	40		7¾		6½		
15	5 E.		5½ W.		15¼ W.		
15	10		7½		16½		
15	40		19¾		20		
15	45		20½		19½		
15	50		20½		16¼		
15	55		19½		12½		
15	60		18¼		9		
15	65		17		6		
15	70		15¼		4¼		
15	75		14		3¼		
15	80		12		2½		
15	85		10		2¼		
15	90		8½		2¼		
15	95		6½		2¾	1780	2¾

Table continued.

Lat.	Long.	Year.	Var.	Year.	Var.	Year.	Var.
15° S.	100° E.	1700	5° W.	1756	3¼° W.		
15	105		3½				
15	110		2½				
20	0		3¼		13½	1775	13¼° W
20	5 W.		1½		11¼		
20	10		0½ E.		8¾		
20	15		1¾		5¾		
20	20		3		3	1772	3¼
20	25		4¾		0		
20	30		6		2½ E.	1800	1¼
20	35		7¾		5	1776	4 E.
20	40		9¼		7½		
20	5 E.		5½ W.		15½ W.		
20	10		7¼		16¼		
20	15		9½		17¾		
20	35		19		22		
20	40		20½		22		
20	45		21¼		21¼		
20	50		21¼		18¾		
20	55		20½		15		
20	60		19½		11¾		
20	65		18¾		8		
20	70		16¾		6	1800	9 W.
20	75		15		4¾		
20	80		13½		4½		
20	85		11½		4¼		
20	90		10		4¾		
20	95		8		4¾		
20	100		6½		4¾		
20	105		4¼		4¾		
25	0		3		12½		
25	5 W.		1		10		
25	10		1 E.		7½		
25	15		2½		4½		
25	20		4		2¾		
25	25		6		1 E.	1772	1¼
25	30		7½		3½	1800	0½
25	35		9¼		6	1776	3½ E.
25	40		11		6½		
25	5 E.		5¼ W.		14½ W.	1775	17 W.
25	10		7¼		16		19
25	85		9½		17¾		
25	40		19½		23½		

Table continued.

Lat.	Long.	Year.	Var.	Year.	Var.	Year.	Var.
25° S.	45° E.	1700	21° W.	1756	23¾° W.		
25	50		22¼		23		
25	55		22½		21		
25	60		22		18	1780	19° W.
25	65		20¼		14½		
25	70		19¼		11¾		
25	75		17¾		9½		
25	80		16¼		8		
25	85		14¾		7¼		
25	90		13		7¼		
25	95		11¼		7		
25	100		9½		6		
30	0		2¼		11¾		
30	5 W.		0½		9½		
30	10		1½ E.		6¼	1772	7
30	15		3¼		3½		
30	20		5		0½		
30	25		7¼		2 E.	1800	1¼
30	30		9		4½		
30	35		11		7¼		
30	5 E.		5 W.		13¾ W.		
30	10		7¼		15½	1775	18
30	15		9½		18		20
30	30		17½		23¼	1780	26½
30	35		20¼		24¾		
30	40		21¾		25¼		
30	45		23		24½		
30	50		23½		23¼		
30	55		23		21		
30	60		21½		18		
30	65		20¼		15		
30	70		18¾		13		
30	75		17¼		11½		
30	80		15¼		10¾		
30	85		14		10¼		
30	90		12½		9½		
30	95		10½		9		
30	100		8¾		9		
35	0		2½ W.		10½	1800	14
35	5 W.		0		9		12¼
35	10		2¼ E.		7¾		10
35	15		4¼		5½		9
35	20		6¾		2¼		

Table continued.

Lat.	Long.	Year.	Var.	Year.	Var.	Year.	Var.
35° S.	25° W.	1700	8¾° E.	1756	0½° E.		
35	30		10¾		3		
35	35		12¾		5¾		
35	5 E.		5 W.		13¼ W.	1772	14½° W
35	10		7¼		15¼		16
35	15		9¾		17½	1800	22½
35	20		12½		19¾	1775	21½
35	25		15¾		22¼	1791	25¼
35	30		18¼		24¾		28
35	35		21		26		
35	40		22¾		26¾		
35	45		24¼		26½		27
35	50		24¾		24¾		
35	55		24¼		23		26
35	60		23		21		
35	65		21½		18¾		
35	70		19¾		16¾		
35	75		18¼		15¼		
35	80		16¾		14¼		
35	85		15		13½		
35	90		13¼		12¾		
40	0		2½		9¼		
40	5 W.		0¾ E.		6¾		
40	10		3¼		4¼		
40	20		5½		1½		
40	25		8		1¼ E.		
40	30		10½		4		
40	5 E.		4½ W.		6½		
40	10		7¼		12 W.		
40	15		9¾		14½	1772	19¼
40	20		12¾		17¼	1776	23½
40	25		16		20		
40	30		19		22¼		
40	35		21¾		25¼	1791	33
40	40		23¾		27		
40	45		25¼		28¼		
40	50		26		27¼		33
40	55		25¼		26		
40	60		24		24½		
40	65		22½		22¾		
40	70		20¾		20¼		26
40	75		19		19½		24

Having thus very briefly noticed the changes to which the *variation of the magnetic needle* is subjected, let us now consider whether the position of the *curves of no variation* is liable to similar changes.

SECTION SECOND.

Direction of the Curves of no Variation.—Changes of their Direction.

The curves of no variation, or the lines separating the variation of an easterly from that of a westerly character, intersect the terrestrial and magnetic equators, and pass through a series of points in the southern and northern hemispheres, where the needle points to the true poles of the world. These points are not, however, on the same meridian, but form an irregular curve, inflected different ways: the laws of magnetism being accelerated or retarded by the local influence of continents and islands, forming different small systems of magnetic forces.

The curves of no variation can be pretty distinctly traced, both in the eastern and western hemispheres. In 1662, in the northern hemisphere, a curve of no variation, which had *east* variation on its *eastern* side, and *west* variation on its *western* side, moved from west to east during two centuries prior to 1662; the lines of east variation moving before it, whilst the lines of west variation followed it. This curve first passed the Azores, then the meridian of London, and, after a certain number of years, the meridian of Paris. But, in the southern hemisphere, there was another curve of no variation, which had *east* variation on its *western* side, and *west* variation on its *eastern* side, moving from east to west. This curve first passed Cape Agulhas, and then the Cape of Good Hope; the westerly variation following it, the same as in the northern hemisphere, but in a contrary direction.

From observations made since the above period, it would seem that the curve of no variation in the northern hemisphere, after passing the meridian of London and Paris, has been stopped in its progress eastward; whilst the curve of no variation in the southern hemisphere still continues its course north-westward.

The variation on the *east* side of the curve of no variation, which passed the meridian of Agulhas in 1600, and extended north and south to a high degree of latitude in both hemispheres, being westerly; and the variation on the *east* side of the curve of no variation, which passed the meridian of London in 1662, being easterly: it follows, that the curve which passed London could not reach beyond the 18th degree of east longitude, as the denomination of the variation was the same eastward of that meridian in 1600 that it now is, namely westerly.

The exact point where the southern curve of no variation passed the northern curve, cannot be satisfactorily ascertained; but observations shew, that whilst the northern curve of no variation was passing through London eastward, the curve of no variation in the southern hemisphere passed westward, nearly in the same parallel of longitude.

In the year 1675, in the latitude of the Cape of Good Hope, and longitude 20° west, the variation was 10° 30′ east. In latitude 24° south, longitude 32° west, the variation was 10° 50′ east. In latitude 16° south, longitude 6° 30′ west, the variation was 0° 40′ east; and in latitude 34° south, and longitude 1° east, there was *no* variation.[1]

Dampier, who, in his voyage to the East Indies in 1669, appears to have paid very particular attention to the variation, informs us,[1] that from 6° of South Lat. and 25° of West Long. till the 37° of South Lat. was intersected by the meridian of Greenwich, the variation was of an easterly character, never exceeding 13°; but at this latter point the easterly variation had decreased to nothing, and, changing its name, became westerly. From hence the westerly variation continued to increase till 47° of East Long. and 25° of South Lat. where it appears to have attained its maximum, about 25° or 26° west; and from this point the variation gradually diminished, till it again assumed another denomination in 10° South Lat. and 125° East Long. From this last point to as far north of the equator (10°), the variation appears to have been, as it still is, influenced by local attractions,—the quantity always small, sometimes east, and sometimes west.

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[1] Hutton's Math. and Phil. Dict. vol. ii. 636.

Captain Cook, in 1772, in latitude 6° south, longitude 16° west, found 9° 30′ westerly variation; and in latitude 24° 40′ south, longitude 28° 51′ west, only 0° 39′ west variation. From this point the westerly variation gradually increased as the southern latitude, and eastern longitude augmented, till 96° of East Long. and 60° 49′ South Lat.; when it had attained its maximum, 43° 45′ west.[1] From this last point eastward the variation rapidly diminished, and changed its denomination in latitude 58° 58′ south, longitude 143° 30′ east.[2]

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[1] Vol. iii. p. 70—72.

But as the route of Admiral D'Entrecasteaux, in 1791, nearly coincides with Dampier's in 1669, the change in the position of the curve of no variation during that interval, will be best illustrated by a comparison of their respective observations.

M. d'Entrecasteaux, in his voyage in search of the unfortunate La Perouse, found the variation in latitude 6° south, longitude 25° west, 7° 15′ west; and in 25° South Lat. and 25° West Long. only 1° 56′ west. From this last point the variation again increased as the west longitude diminished, till in the meridian of Greenwich, intersected by 38° of South Lat. the variation was found to be 15° west. The variation attained its maximum, 30° 48′ 9″, in latitude 34° 52′ south, longitude 38° 14′ 18″ east from Paris; and from this point, till 133° East Long. and 44° South Lat. the variation continued westerly; but it there changed its name, and became easterly.

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[1] This is the greatest variation ever observed in the southern hemisphere.

[2] Wales' Astron. Obs. pp. 369, 370.

As D'Entrecasteaux, in 25° South Lat. and 25° West Long. from Paris, or 22° 40′ from Greenwich, found the variation only 1° 56′ west, it is probable that, had he gone 2° or 3° further west, he would have cut the curve of no variation.[1]

The space between the two curves observed by Dampier in 1699, reached from the meridian of Greenwich to 130 East Long. The distance between them, according to D'Entrecasteaux in 1791, must be 155°, Dampier having cut the curve in 80° 0′ Long.; the other in 25° West Long. The curve of no variation must, therefore, have advanced westward annually about 16′ in the parallel of 34° South Lat. to have shifted its place 25° in 92 years, and, at an yearly rate of 14′ 8″, from the time it passed Cape Agulhas in 1600 to 1791. This curve is now ascertained to extend across the magnetic and terrestrial equators to a point in Lat. 87° 27′ north, Long. 70° 44′ west; but we shall notice this more fully hereafter.

Dampier, as already observed, found the curve of no variation in Lat. 10° south, Long. 125° east; and Captain Cook found it in Lat. 58° 53′ south, Long. 143° 30′ east. La Perouse cut it in Lat. 20° 48′ north, Long. 129° 8′ east; again in Lat. 40° 20′ north, Long. 130° 20′ east; and again in Lat. 51° 29′ north, Long. 142° 26′ east.[1] D'Entrecasteaux in 1791, cut it in Lat. 38° 14′ 18″ south, Long. 133° east; and four months afterwards, in 2° 28′ 38″ south, Long. 129° 15′ east. Flinders found it in Lat. 32° south, Long. 132½° east. The Russian navigator, Krusenstern, in his voyage of discovery, cut it in Lat. 31° north, Long. 144° east; and he also found the same curve extended to a point in Lat. 52° north, Long. 143° east.

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[1] Labillardiere's Voy. vol. ii. App. p. 4, 6, 8, 12.

From these facts it follows, that a curve of no variation, bending westward, extends from the highest degree of southern Lat. in about 144° East Long. to Lat. 52° north in the same parallel: It intersects the equator in 130° East Long.

It is necessary to recollect, that the magnetic needle, influenced by local attractions in the great Asian Archipelago, frequently indicates variations of different denominations; but this circumstance nowise affects the general conclusions.

Before proceeding to trace the variation eastward from the points we have just noticed the curve of no variation to pass through, we shall briefly inquire into its direction from the points where La Perouse and Krusenstern found it to terminate.

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[1] La Perouse, vol. ii. p. 224, 240, 250, 256.

From their observations, the westerly variation ceased, and the curve of no variation terminated, about 52° North Lat. and 148° East Long.; for the variation north-east of this point assumes another character; and 18° further north, and 52° to the east, Captain Cook found near 36° of easterly variation.

From observations made in Persia and the frontiers of China by the astronomer Schubert, it would seem that a line of no variation (for a very small variation only was found in the tract he passed over) is connected with the curve of no variation observed on the eastern coasts of China, Japan, &c. by La Perouse and Krusenstern; and if the observations made on board his Majesty's ship Sybille, in Lat. 73° 59′ north, Long, 29° 55′ east, are nearly accurate, it is extremely probable, that this curve of no variation takes its rise in about 52° North Lat. and 143° East Long. and terminates a little eastward from Spitzbergen, extending in a direction nearly east by south, and west by north, through 6780 miles of longitude.

M. Biot makes the following remarks respecting this curve.

" There exists another band without declination (variation) nearly opposite the former,[1] the latter continually pointing towards the north-west: takes its rise in the great Southern Ocean, passes through the western point of New Holland, traverses the Indian Ocean, enters the continent of Asia at Cape Comorin, and from thence passes through Persia and West Siberia, and proceeds towards Lapland. But what is very remarkable, that line divides itself into two near the great Asian Archipelago, and gives rise to another branch, which directing itself directly from the south to the north, passes that Archipelago, traverses China, and is again found in Eastern Siberia. The existence of this branch, and its separation from the former, are clearly indicated by the observations made in the China seas; but I am able to offer a still stronger confirmation in the declinations (variations) observed in Russia, and the frontiers of China, by the celebrated astronomer Schubert, who has been kind enough to communicate them to me. Having gone in the summer of 1805 from Casan to Tobolsk, and from Tobolsk to Irkutsk, he met successively the two branches which we have just described, in their northern parts where they are furthest se-parated, as is proved by the following observations."[1]

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[1] Meaning the curve of no variation in the western hemisphere.

The following Table contains the observations M. Biot alludes to; and those of La Perouse, Krusenstern, &c. in nearly similar latitudes.

Authority.	Lat. North.	Long. in Time East from Paris.	Long. East from Greenwich.	Declination or Variation.	Dip of the Needle.	Names of Places.
	° '	h. ' '	° ' "	° '	° '	
La Perouse.	20 48		129 8 0	0 0		
	37 17		135 17 0	0 20 E.	47 0	
—	40 20		136 20 0	0 0	48 5	
—	51 29		142 26 0	0 50	71 0	
Krusenstern.	53 0		158 40 0	5 20 W.	63 32	
	50 28		156 59 0	5 29		
—	51 17		153 19 0	0 57		
—	46 2		143 30 0	1 20 E.		
—	40 50		140 6 0	0 4 W.		
Shubert.	52 17	6 47 25	104 11 15	0 32 E.	67 0	Irkutsk.
—	54 55	6 26 46	99 1 30	2 40	78 0	Nisk-Udinsk.
—	56 0	5 30 0	82 50 30	5 37	—	Touisk.
—	56 54½	4 42 27	72 56 0	6 6	—	Taro.
—	58 12	4 18 30	66 57 30	7 9	—	Tobolsk.
—	56 51	3 48 58	59 34 15	5 40	—	Catherineburg
—	58 1	3 31 46	55 15 30	1 1	—	Pekin.
—	55 48	3 3 38	48 14 30	2 2½	—	Casan.
Bain.	73 59		29 59 0	4 55 W.	—	

We have just seen, that a curve of no variation extending from 60° of South Lat. to 52° of nation (variation) nearly opposite the former,[1] the latter continually pointing towards the north-west; takes its rise in the great Southern Ocean, passes through the western point of New Holland, traverses the Indian Ocean, enters the continent of Asia at Cape Comorin, and from thence passes through Persia and West Siberia, and proceeds towards Lapland. But what is very remarkable, that line divides itself into two near the great Asian Archipelago, and gives rise to another branch, which directing itself directly from the south to the north, passes that Archipelago, traverses China, and is again found in Eastern Siberia. The existence of this branch, and its separation from the former, are clearly indicated by the observations made in the China seas; but I am able to offer a still stronger confirmation in the declinations (variations) observed in Russia, and the frontiers of China, by the celebrated astronomer Schubert, who has been kind enough to communicate them to me. Having gone in the summer of 1805 from Casan to Tobolsk, and from Tobolsk to Irkutsk, he met successively the two branches which we have just described, in their northern parts where they are furthest se-parated, as is proved by the following observations."[1]

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[1] Biot. Traitè de Physique, tom. iii. p. 136. I have ventured to differ with M. Biot, in considering the variations in the Indian Ocean as rather influenced by local attractions acting in opposite directions, than as being intersected by a curve of no variation. However, as the variations are there exceedingly small, either hypothesis may be adopted.

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[1] Meaning the curve of no variation in the western hemisphere.

The following Table contains the observations M. Biot alludes to; and those of La Perouse, Krusenstern, &c. in nearly similar latitudes.

Authority.	Lat. North.	Long. in Time East from Paris.	Long. East from Greenwich.	Declination or Variation.	Dip of the Needle.	Names of Places.
	° ′	h. ′ ′	° ′ ″	° ′	° ′	
La Perouse.	20 48		129 8 0	0 0		
	37 17		135 17 0	0 20 E.	47 0	
—	40 20		136 20 0	0 0	48 5	
—	51 29		142 26 0	0 50	71 0	
Krusenstern.	53 0		158 40 0	5 20 W.	63 32	
	50 28		156 59 0	5 29		
—	51 17		153 19 0	0 57		
—	46 2		143 30 0	1 20 E.		
—	40 50		140 6 0	0 4 W.		
Shubert.	52 17	6 47 25	104 11 15	0 32 E.	67 0	Irkutsk.
—	54 55	6 26 46	99 1 30	2 40	78 0	Nisk-Udinsk.
—	56 0	5 30 0	82 50 30	5 37	—	Touisk.
—	56 54½	4 42 27	72 56 0	6 6	—	Taro.
—	58 12	4 18 30	66 57 30	7 9	—	Tobolsk.
—	56 51	3 48 58	59 34 15	5 40	—	Catherineburg
—	58 1	3 31 46	55 15 30	1 1	—	Pekin.
—	55 48	3 3 38	48 14 30	2 2½	—	Casan.
Bain.	73 59		29 59 0	4 55 W.	—	

We have just seen, that a curve of no variation extending from 60° of South Lat. to 52° of

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[1] Biot. Traitè de Physique, tom. iii. p. 136. I have ventured to differ with M. Biot, in considering the variations in the Indian Ocean as rather influenced by local attractions acting in opposite directions, than as being intersected by a curve of no variation. However, as the variations are there exceedingly small, either hypothesis may be adopted.

North Lat. in about 143° East Long. but taking a small bend westward, is intersected by the meridian of Amboyna. We shall now trace the variation from this line, till it again changes its denomination.

Mr Wales, the able astronomer to Captain Cook, found a curve of no variation in Lat. 58° 27′ south, Long. 346° 50′ east, (13° 10′ west);[1] La Perouse cut the curve of no variation in 20° 39′ south, Long. 28° 38′ west;[2] and from thence the variation continued easterly round Cape Horn, until he again intersected the curve of no variation in Long. 143° east.

In October 1791, Vancouver cut the curve of no variation about 37° North Lat. Long. 130° east. The variation did not subsequently change its name till the 16th of June 1795, and during this long period, he was often as far north as 60° and 61° of Lat. After Vancouver left the north-west coast of America to proceed homeward round Cape Horn, the variation was always easterly. In Long. 270° east, (Pacific Ocean,) on the equator, the variation was 7°; and from this point the variation increased as the south latitude augmented, till off Cape Horn, where it was 23° east. As he proceeded north from Cape Horn, the variation gradually diminished, till it changed its name in Lat. 35° south, and Long. 28° west.

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[1] Wales' Astro. Tables, p. 382.

[2] La Perouse, vol. ii. p. 136.

Speaking of the variation, Vancouver says, "the eastward variation seemed to have ceased about the 16th of June 1795, as in Lat. 35° south, Long. 332° 5′ east, (27° 25′ west,) it had decreased to 0° 16′, and since that period the westerly variation had been gradually increasing as we proceeded to the northward."[1]

Sir Home Popham, January 25th 1801, found only 0° 45′ of westerly variation in Lat. 30° south, Long. 26° west.[2]

Humboldt says, "On comparing the observations made during several voyages, it appears we had cut the curve of no variation in Lat. 13° north, between Long. 58° and 65° west. This curve is now prolonged towards Cape Hattras, and towards a point in Lat. 37° 27′ north, Long. 70° 44′ west."[3]

Hence it appears, that from the most westerly part of the curve of no variation found in about 130° east from the meridian of Greenwich, where the westerly changes to an easterly variation, to the meridian where the easterly variation was found to terminate by Captain Cook in

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[1] Vancouver's Voyage round the World.

[2] Clarke's Maritime Discovery, vol. i. App. p. 259.

[3] Humboldt, Personal Narrative, vol. ii. p. 118.

Lat. 58° 27′ south, Long. 13° 10′ west, the distance east and west will be 216° 50′.—To the meridian of La Perouse, in Lat. 20° 32′ south, Long. 28° 38′ west, 201° 22′.—To the meridian of Vancouver, in Lat. 35° south, Long. 28° west, 202°.—To the meridian of Sir Home Popham, in Lat. 30° south, Long. 26° west, 204°.—To the meridian of Humboldt, in Lat. 13° north, Long. 59° west, (taking the mean,) 171°. And if the curve of no variation extends to Lat. 87° 27′ north, Long. 70° 40′ west, the space of easterly variation in that parallel will only be 158° 16′.

These different distances point out, under different parallels of latitude, the direction which the curve of no variation at present assumes; and we may perhaps conclude, that the variation of the magnetic needle is caused by two separate and distinct systems of magnetic forces; the one producing a westerly variation in the northern hemisphere, over a space of 200° 44′; and in the southern hemisphere, in the same parallel of latitude of 143° 10′: and the other, an easterly variation in the northern hemisphere, over a space of 159° 16′; and in the southern of 216° 50′.[1]

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[1] It is necessary, however, to bear in mind, that the greater part of the continent of Europe, Persia, China, Tartary, Kamtschatka, and the whole of the great Asian Archipelago, on the east; Barbadoes, Jamaica, and perhaps the whole of the

From these facts, it would seem that the north end of the curve which passed Cape Agulhas in 1600 north-westward, was, in 1804, found to extend from 60 South Lat. in 13° 10′ West Long. to 37° 27′ North Lat., and 70° 40′ West Long.; intersecting the 18th degree of North; 21st, 30th, and 35th degree of South Lat: hence the average rate of its movement has been nearly 26½′ annually; but it is extremely probable that the south end of this curve has, during the same period, remained stationary; and this difference in the movement of the two extremes of the curve of no variation in the southern hemisphere, may perhaps point out to us the reason why the quantity of variation should have continued the same off Cape Horn during 133 years; whilst, at the Cape of Good Hope, Paris, and London, it should have increased 25° or 27° in the same period.

The curve of no variation which passed through London eastward about the same time the curve in the southern hemisphere passed the meridian of Greenwich westward, appears to have been lost among the smaller magnetic powers at present found in the continent of Europe and Asia.

Caribbean sea, on the west; form so many different small systems of magnetic forces, as to render it difficult to determine to which of the greater systems they belong.

The view which we have given of this perplexing subject, deduced from actual observations, renders it obvious, that all attempts by *theory* to fix on charts the exact positions of curves of no variation, or lines of given variation, must (as they have hitherto been) prove abortive.[1]

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[1] We owe the first variation chart, published in 1700, to the celebrated Dr Halley. Previous to this period, he had collected, and made, a multitude of observations on the variation of the needle in many parts of the world, and was enabled to draw, on a Mercator's Chart, lines shewing the variation of the compass in the places through which they passed. But as the deviation of the magnetic meridian from the true one was then as now, subject to continual alteration, this chart was soon found useless.

However, in 1744, Mountain and Dobson published a new Variation Chart, adapted to that year; which being well received, they published a second adapted to 1756; and a third in the following year,—the last we know of.

Nicholson strongly recommends the employment of the variation as a means of finding the longitude at sea; but navigators are long since convinced of its inadequacy. Vancouver, speaking of this subject, says, "This very able seaman Nicholson, still wedded to formerly adopted opinions, strongly recommends the variation of the compass as a means for ascertaining the longitude at sea; yet, had we been no better provided, we might have searched for the Cape of Good Hope, agreeable to his propositions, to little effect; for when we were in Lat. 35° 7′ south, with 20° 16′ west variation, we had only reached the Long. of 6° 30′ west; and again, when in Lat. 35° 22′ south, with 22° 7′ west variation, we had only advanced to the Long. of 11° 25′, instead of being, according to Mr Nicholson's hypothesis, in the first instance, nearly under the meridian of the Cape of Good Hope, and in the second under that of Cape Agulhas; and it was not until

There are, indeed, places in the world, such as Spitzbergen, Cape Horn, Chili and Mexico, the great Asian Archipelago, coasts of Coromandel, Pegu, Brazil, &c. where the curve of no variation, and the variation itself, has not undergone any perceptible change since first observed; but we have good grounds for believing, that, at all the above mentioned places, the variations are regulated by incidental magnetic attractions, which are lost or merged in the two great powers already described, at a little distance from their respective spheres. In all other places of the globe, the variation is continually undergoing a regular and progressive

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we had near 26° of west variation, that we approached the meridian of the Cape of Good Hope. The observations for the variation were made with the greatest care and attention; and though generally considered as correct, they differed from one to three, and sometimes to four degrees; not only when made by different compasses, placed in different situations on board, and the ship on different *tacks*, but by the same compass in the same situation, and at moderate intervals of time; the difference in the results of such observations, at the same time, not preserving the least degree of uniformity. Hence the assertion amounts nearly to an absurdity which states, 'that with 20° to 20° 10′, or 20° 30′ westerly variation, you will be certain' of such and such longitudes; and it is greatly to be feared, that navigators who rely on such means for ascertaining their situation in the ocean, will render themselves liable to errors that may be attended with the most fatal consequences."—VANCOUVER'S *Voyage round the World*, p. 15.

change; but it is impossible accurately to determine when this change may stop, or to foresee what quantity our westerly variation may attain.

SECTION THIRD.

Inquiry concerning the Dip of the Magnetic Needle—Tables of Dip in various Latitudes.

The magnetic needle is not only affected by a force causing it to diverge *eastward* and *westward* from the true meridian; but it is also affected by a force acting in a *vertical* direction, producing what is called the *dip* or inclination of the needle; or forming an angle between the needle and the plane of the horizon, which has indifferently received these names.

A line passing through those points on the surface of the globe where the dip or inclination is nothing, or where the needle is parallel to the horizon, forms what is called the MAGNETIC EQUATOR.

From the learned researches of M. Biot, it appears that the magnetic equator is inclined to the terrestrial equator, or forms an angle with it of about 12°; and that it intersects the terrestrial equator near the island of Gallego in about 115° 34′ West Long. reckoning from Paris; and of course has the opposite point of intersection in 295° 34′ West Long.: But although this position of the magnetic equator nearly corresponds with observations in a considerable portion of the globe, it is altogether different in the space between 115° and 270° of West Long. Bayley and Cook, in different vessels, found the magnetic equator in 158 50′ West Long. and 3° 13′ 40″ of South Lat.; whilst the great circle determined from observations made in other parts of the globe, and from theory, would have intersected that meridian in 8° 36′ 30″ of North Lat. It is therefore certain, continues M. Biot, that the magnetic equator, in about 115° West Long. *redescends* into the southern hemisphere; and as the observations of Bayley, confirmed by Dalrymple, shew, of new, the magnetic equator towards 7° of North Lat. in the Chinese seas at 256° West Long.; we must conclude, that, between that longitude and that of 158° 50′ determined by Cook, the magnetic and terrestrial equator again intersect each other, independently of the point of intersection dependent on the circular part.[1]

When the dip or inclination of the needle was first observed by Norman, theories were formed to account for the cause of such a surprising phenomenon, and it was attempted to discover the latitude by its observation. It was soon, however, found not to answer that purpose; and has since been adverted to more as a matter of curiosity than utility. But since the voyage of Captain Flinders has been published, the observations respecting the dip have become of paramount importance; and as we shall have occasion frequently to refer to this element, in our subsequent reasoning, it will be necessary to enter into the matter at some length.

At London, in 1592, Norman found the north end of his dipping needle to be inclined 71° 50′ below the plane of the horizon. In 1772, the dip was ascertained by Nairne to be 72°; and he adds, "The difference between these observations, taken at such distant periods of time, is smaller than that found between several of his (Nairne's) observations compared with each other; and, therefore, we have no reason to conclude that the dip has altered since Norman's time. The care with which his instrument was constructed, and observations made, leaves no room to doubt of their accuracy."

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[1] Biot, Traitè de Physique, tom. iii. p. 131.

But although the above observations appear, from the lapse of 180 years, to be nearly conclusive, as to the dip remaining the same at London, later investigations have induced Humboldt and Biot to conclude, that there are perceptible variations in the dip at that city and Paris in much shorter intervals of time.

In London, in 1775, the dip was observed with great care to be 72 30′; and in 1805, 70° 24′. At Paris, in 1798, it amounted to 69° 51′; in 1806, to 69 12′; in 1810, to 68 50′; and in 1812, it was ascertained to be 68° 42′: Hence it results, that from 1775 to 1805, the dip diminished 4′ 18″ annually at London; and at Paris, from 1798 to 1812, its yearly decrease was equal to 4′ 64″.[1]

But supposing these late observations to have been made with the greatest care and attention, still they are of such a very difficult nature[2] as to preclude the possibility of the precise quantity of inclination being obtained; and as differences at very short intervals are always perceptible, they certainly tend to confirm the idea of the dip being stationary, or at least nearly so; and that the differences are resolvable into errors of observation. At all events, before any certain conclusion can be drawn to confirm the opposite opinion, we must wait till a series of observations, carefully made with delicate instruments in different parts of the globe, and at distant intervals, shall have established the fact.

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[1] Humboldt's Personal Narrative, vol. 2. p. 112.

[2] When Mr Bayley went on shore at the Cape of Good Hope to ascertain the dip, his instrument was so much out of order, and so difficult to put to rights, that, notwithstanding he spent all the leisure time he had from other observations in attempting to adjust it, he had not succeeded before he was obliged to set sail. We find Mr Bayley frequently com-

Extremely few, and only insulated, observations were made respecting the dip previous to the voyages of Captains Cook and Phipps; though the dipping needle was recommended by Mr Rook, fellow of the Royal Society, as far back as 1666.[1]

Some navigators and philosophers have been of opinion, that the magnetic force causing the variation, and the dip, were essentially the same; and that the quantity of the one was in every case proportional to that of the other. In conformity with this opinion, it has been maintained, that the variation augments precisely as the

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plaining, during the course of the voyage, of the trouble with which the adjustment of the dipping needle was attended.

[1] Clarke's Maritime Discovery, App. p. 168.

dip augments after leaving the magnetic equator; and hence it has been concluded, that if the dip in different latitudes was known, the variation would directly be obtained, and *vice versa.* A very few facts, however, will suffice to shew, that if the force producing the dip, and that producing the variation, are really the same, its manifestations in the two cases are entirely dissimilar, and appear totally unconnected.

We have just seen that Norman, in 1592, observed the dip at London to amount to 71° 50′; and that late observations have shewn it has remained nearly stationary; but in the same period, the variation has changed not less than 38°. This fact of itself is decisive of the question.

Captain Phipps, in Lat. 80° north, in the parallel of Spitzbergen, ascertained the dip to be 82° 8¾′; whilst at the same place, the variation was only 12° west; and the same gentleman found the dip of Harwich between 72° and 73°, whilst the variation amounted to 16° 50′.[1]

Mr Bayley ascertained the dip at Drake's island (Plymouth) to be 72° 5′, whilst the variation was 21° 29′ west. At Fyal, in Lat. 38° 32′ north, Long. 28° 21′ west, the same gentleman found the dip 71° 1′ north, with a variation of

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[1] Voyage towards the North Pole.

22° 7¼′ west; and again, in Lat. 7° 56′ south, Long. 14° 32′ west, the variation was 10° 52½′ west, whilst the dip was observed to be only 8° 57½′.[1]

The observations made on the dip by La Perouse in the Boussole, and those made in the Astrolabe, the ship which accompanied him on his voyage of discovery, are exceedingly numerous. The extreme difficulty, however, of making the observations, has caused a considerable difference in the results; and in many instances, where the latitude and longitude were the same in both ships, the observed dip differs from 2° to 27°. The dipping instruments used on this occasion by La Perouse, had belonged to the immortal Cook: The British government nobly forgetting national animosities, voluntarily presented them to the most illustrious of foreign navigators, with whom they have unfortunately been entombed in the bosom of the deep.

From the observations made on the dip by La Perouse, it is seen, that in Lat. 11° north, Long. 25° 25′ west,[2] with 10° 30′ west variation, the dip was only 20°. In Lat. 10° 57′ south, Long. 25° 25′ west, variation 5° 20′ west, there was *no* dip. In Lat. 20° 39′ south, Long. 31° 24′ west, variation 0° 57′ east, 11° of dip was found. In Lat. 58° 24′ south, Long. 74° 37′ west, with 25° 38′ east variation, the dip was 68°. In Lat. 26° 24′ south, Long. 112° 6′ west, with 2° 26′ east variation, the dip was 41°. In Lat. 0° 18′ north, Long 116° 33′ west, variation 2° 58′ east, there was no dip. In Lat. 32° 34′ north, Long. 123° 50′ east from Paris, with no variation, the dip was 45° 5′. And in Lat. 51° 29′ north, Long. 140° 26′ east, with 71° of dip, the variation was only 0° 50′ east.

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[1] Wales' Astronom. Observations.

[2] The longitude here given is reckoned from Paris.

The observations made on the dip by Vancouver, on the north-west coast of America, assume a more corresponding regularity, though not always proportional to the increase or decrease of latitude and variation.

The observations made by D'Entrecasteaux, though not so numerous as those we have just noticed, are nevertheless very valuable, and are sufficient to disprove the theory in question.

At the Cape of Good Hope, the variation was ascertained to be 24° 31′ 52″ west, but the dip only amounted to 47° 25′; whereas in Lat. 43° 35′ south, Long. 144° 37′ east from Paris, with only 2° 25′ of westerly variation, the dip was 71° 30′.

The observations made on the dip by the Russian navigator Krusenstern, are very limited; owing to an accident happening his dipping instrument at an early period of his voyage. Those he did make, however, nearly correspond with those of La Perouse, and establish two important facts: First, that off Cape Horn, the dipping needle appears to be attracted by the same degree of magnetic strength with which it is affected at Paris and London. But the variation at these cities has increased, during 137 years, from zero to 27°, whilst, during the same period, the dip has remained stationary; whereas at Cape Horn, *both* variation and dip have continued the same since first observed. Second, that on the coasts of China, Tartary, Japan, Corea, Kamtschatka, &c. the power by which the variation is produced, is extremely weak and feeble; and the magnetic force by which the dipping needle is influenced, always strong and powerful.

The observations made on the dip during Captain Flinders' voyage to Terra Australis, are sufficiently numerous; but as they are confined to a small space, offer nothing very interesting, if we except the use to which that excellent navigator applies them. But as that subject requires a distinct investigation, we shall, for the present, defer entering on it.

As the results obtained by such an excellent observer as M. Humboldt are well entitled to more than ordinary notice, I have extracted all the observations made on the dip in his voyage to America.

The following Tables, containing a very considerable portion of the observations hitherto made on the dip, are inserted with a view not only of easy reference in our subsequent inquiries respecting the *changes in the variation*; but also, that the navigator may have it in his power easily to apply them to the examination of Captain Flinders' *Rule* for determining the *true* variation.

Observations Made on the Marine Dipping Needle, by Captain PHIPPS, *in his Majesty's Ship Race Horse, in a Voyage towards the North Pole, in* 1773.

Lat. North.	Long.	Dip.	Variation.	Remarks, &c.
		North.	West.	
51° 35′		73° 31′		Near the Buoy of the Upper Middle.
		73 35		
		72 12		Off Harwich.
		73 22	16°37½′	In Southwold Bay.
		73 30	21 53	
		75 18	23 46	Off Shetland, Lat. 60° 18′.
		74 52		
		75 0		
		76 45		
70 45		77 52		
72 40		81 30		
73 22		80 35		
73 26		79 30	7 47	
74 30		79 22		
77 47		81 7	11 38	
78 2		80 26		
78 8		79 31		
78 24		80 45	14 55	
80 12		81 52		
		81 52½	20 38	On shore, Lat. 79° 50′.
		82 7½		
80 27		82 2½		
		82 8¾	18 57	At Smeerenberg, Lat. 79° 44′.
69 2		79 4		

Observations made on the Marine Dipping Needle by, Captain Cook, *in his Majesty's Ship Resolution, in a Voyage round the World, in* 1777, 1778, 1779, *and* 1780.

Lat.	Long.	Dip.	Variation.	Place.
16° 45′ S.	208° 15′ E.	29° 5′	6° 19′ E.	Ohamaneno Harb.
16 42½ S.	208 52 E.	28 28	5 13½ E.	Owharre Harbour.
17 29¼ S.	210 22½ E.	29 12	5 34 E.	Matavai Point.
1 15 N.	202 30 E.	11 54 N.	6 22½	Christmas Island.
21 56 N.	200 13 E.	42 1 N.	10 17 E.	Sandwich Islands.
49 36 N.	233 17½ E.	72 28 N.	19 44 E.	Nootka Sound.
64 31 N.	197 13 E.	76 25 N.	25 45 E.	Norton Sound.
53 5 N.	193 30 E.	69 2 N.	19 59 E.	Oonalashka.
19 28 N.	204 0 E.	40 31 N.	8 6 E.	Owhyhee.
53 0½ N.	158 43	63 5 N.	6 18 40	Kamtschatka.
22 12 N.	113 47	21 1 N.	0 19 W.	Macas.
8 40 N.	106 19	2 1	0 14	Pulo Candore.
8 6 S.	104 48	26 3	1 0	Island of Cracatoa.
6 36	105 17	28 15	0 54	Prince's Island.
34 20	18 29	46 47	22 16	Simon's Bay.
12 48	15 40 W.	No Dip.		At Sea.

Observations made on the Marine Dipping Needle, by Mr Bayley, *in his Majesty's Ship Adventure, in a Voyage round the World, in* 1772, 1773, 1774, *and* 1775.—(Wales' *Astronomical Tables.*)

Lat.	Long.	Dip.	Variation.	Remarks, &c.
52° 21′ N.	4° 16′ W.	72° 5′	21° 29′ W.	Drake's Isl. (Plymouth).
33 55 S.	18 23 E.	45 37	20 26¼	Cape of Good Hope.
45 47	166 18	70 7	14 5 E.	Dusky B. New Zealand.
41 6	174 18½	64 13	13 46	Q. Charlotte's Sound.
17 29½	210 25	29 58	5 46	Otaheite.
19 32½	169 49	45 2	7 14	Tama, New Hebrides.
20 18	163 57	—	8 32½	Padyouda Island.
55 22	289 57	66 53	24 30	Christmas Sound.
7 56	14 32 W.	8 57½	10 52½ W.	Ascension Island.
38 32 N.	28 26	71 1	22 7¼	Fayal.

Observations made on the Dipping Needle, and variation of the Compass, during a Voyage round the World by M. De La Perouse, *in* 1785, 1786, 1787, *and* 1788, *on board the Boussole.*

Lat.	West from Paris. Long.	Variation.	Dip.	Remarks.
11° 2°N.	22°40′W	10°23′W.	20° 0′N.	
0 42 S.	21 47	9 50	17 0	
5 37	23 32	8 43	10 30	
10 57	25 25	5 50	0 0	
12 14	25 56	5 30	0 13 S.	
15 46	27 2	3 34	4 0	
20 38	30 33	1 1	13 45	
20 39	31 24	0 57 E.	14 0	
20 34	35 21	1 42	17 15	
25 3	42 1	4 55	20 0	
26 51	49 35	12 12	29 30	
27 21	50 0	12 0	30 30	
31 34	46 20	7 31	33 0	
44 34	35 38	6 59	50 0	
44 0	39 10	9 20	51 0	
42 9	51 58	14 17	50 0	
45 31	60 48	18 18	55 30	
47 58	63 22	20 19	59 15	
50 57	70 45	21 22	51 0	
54 35	69 3	21 0	63 0	
58 24	74 37	25 38	68 0	
59 20	80 26		72 15	
33 44	78 57	14 11	49 0	
27 3	103 37	6 31	42 45	
26 24	112 6	2 26	41 0	
0 54	116 2	2 56	1 0	
0 18 N.	116 33	2 58	0 0	
1 40½	117 11	1 1	0 20 *	* In the voyage, it is not indicated whether this be North or South Dip; but I apprehend it is North Dip.
5 49	119 46	1 2	5 0	
20 3.	140 52	6 51	33 0	
20 34	158 25	8 40	28 0	
33 54	159 31	11 40	49 30	
50 5	148 29	22 50	66 30	
57 46	143 42	27 40	74 0	
59 7	140 52	31 22	76 0	
52 35	134 1	27 56	78 0	
32 34	123 50 E.	0 0	45 5	
36 41	128 11	1 54	45 30	
46 8	136 24	1 10	58 0	
48 31	139 11	2 33	63 0	
48 4	140 16	1 0	63 3	
51 29	140 26	0 50	71 0	

Observations made on the Marine Dipping Needle by M. De Langle, *in the Astrolabe, during a Voyage round the World, in company with* M. De La Perouse.

Lat.	Long.	Variations.	Dip.	Remarks.
14° 11′ N.	22° 11′ W.	11° 30′ W.	32° 15′	
0 40 S.	18 29	9 36	8 15	
3 42	20 50	8 32	2 0	
11 4	23 19			
12 19	23 52	3 49	11 0	
15 52	25 21	4 30		
20 43	28 53	1 0 E.		
20 42	29 51	1 28	26 30	
26 5	39 36	7 6		
27 0	49 39	9 55		
44 1	36 4	8 45		
50 58	70 29	23 18	64 30	
54 53	67 58		68 15	
58 22	74 22	27 3	69 37	
33 40	79 6	14 0		
27 6	104 49	7 37	53 0	
0 12 N.	119 10	3 50		
1 36	119 29	4 8	27 19	

Observations made on the Marine Dipping Needle, by Admiral D'Entrecasteaux, *in a Voyage in search of M. De La Perouse, in* 1791, 92, *and* 93.—(Labillardiere's *Voyage*, vol. ii.)

Lat.	Long.	Variation.	Dip.	Remarks, &c.
			72° 56′	Paris.
			71 30	Brest.
33° 54′ S	16° 4′	24° 32′ W	47 25	Cape of Good Hope.
43 32	144 46	7 39 E.	70 30	Van Dieman's Land.
43 35	144 37	2 25	71 30	Van Dieman's Land.
3 22	121 1	0 54	20 30	Cayelee, Isle of Buro.
7 14	110 36	2 31	25 0	Samarang, Java.
		21 31 W	62 25	Teneriffe.[1]

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[1] The Longitude is from Paris.

Observations made on the Marine Dipping Needle, by Captain VANCOUVER, *in a Voyage Round the World, in his Majesty's Ship Discovery, in* 1791, 92, 93, 94, *and* 95.

Lat.	Long.	Variation.	Dip.	Remarks, &c.
		25°40′W	48° 30′	Cape of Good Hope.
35° 5′ S.	118°14′E	5 20	64 54	King George's Sound.
17 30	210 24	6 12E.	30 53	Otaheite.
48 2½N.	237 27	21 30	74 30	Port Discovery.
48 53½	237 33	19 30	73 13	Birch Bay.
49 34	233 31	18 22	73 56	Nootka Sound.
36 36	238 26	12 22	63 30	Monterry Observatory.
19 28	203 58	7 47	41 24	Karakokooa.
55 16	230 16	25 18	75 54¼	
34 41	243 7	11 0	59 13	Port St Diego.
60 16	213 32	28 30	77 8½	
58 12	223 55	30 0	78 58	
5 35	273 5½	7 45	19 45	
2 3S.		7 45	0 30	
		7 50	1 31	
4 15	265 15	9 7	5 55	
12 43	260 32	4 55	23 18	
19 24	253 45	2 45	35 23	
33 1¼	288 29	14 49	44 15	

Observations made on the Marine Dipping Needle, by Captain KRUSENSTERN, *in a Voyage Round the World, in* 1803, 1804, 1805, *and* 1806.

Lat.	Long.	Variation.	Dip.	Remarks, &c.
58° 59′S	63° 47′W	24° 32′E	73° 15′	
55 46	80 0	19 59	75 0	
3 27	144 40	5 18	13 0	
0 56	146 16	4 34W	8 30	
1 12N.	146 46	5 18	—	
40 50	219 54	0 4	—	
46 2	216 30	1 20E.	—	
57 17	206 41	0 57W	—	
50 28	203 1	5 29	—	
53 0	201 16	5 20	63 32	

Observations made on the Marine Dipping Needle, by M. HUMBOLDT, *in the North Atlantic Ocean, in* 1799.—(Humboldt's *Personal Narrative,* vol. ii.)

Lat.	Long.	Dip. Centesimal Division.	Remarks, &c.
38°52′N	16°22′W	75° 76′	The Longitude is reckoned from Paris.
37 26	16 32	75 35	
34 30	16 55	73 0	
31 46	17 4	71 90	
28 28	18 33	69 35	
24 53	20 58	67 60	
21 29	25 42	64 65	
19 54	28 45	65 52	
14 15	48 3	56 30	
13 2	53 15	50 67	
11 1	54 41	47 5	
10 46	60 54	46 95	

SECTION FOURTH.

Observations establishing a Change of the Variation, consequent on a Change in the Position of the Ship's Head relatively to the Meridian—Fatal Effects of not adverting to this Change in determining the Ship's Place, exemplified in various instances.

The easterly and westerly variation of the magnetic needle, resulting from the general laws of magnetism, was long imagined to be the exact quantity of the variation found on shipboard. Facts, indeed, often transpired to render this opinion doubtful, but it is only of late that it has been completely established, that the variation found on shipboard varies with every variation of the ship's position in respect to the meridian, though otherwise the ship should remain in precisely the same place; or that a different variation will be observed on every point of the compass towards which the ship's head may be directed.

There have been no navigators of celebrity, who, during their respective voyages, do not frequently allude to great irregularities found in the variation of the compass; but it was long concluded that these irregularities arose from the imperfect formation of the *azimuth compass*, and not from any general and permanent cause.

Dampier, whose correct judgment, knowledge, and experience, renders his observations and suggestions of double weight, adverts to these irregularities as follows:

"Another thing that stumbled me here was the variation, which at this time, by the last amplitude I had, I found to be but 7° 38′ west; whereas the variation at the Cape of Good Hope was then computed, and truly, about 11°; and yet a while after this, when I had got ten leagues to the eastward of the Cape, I found the variation but 10° 45′ west; whereas it should have been more than at the Cape. These things I confess did puzzle me," &c.[1]

Had Dampier noted the direction of the ship's head at the time these observations were taken, it is highly probable this puzzling circumstance, to which he alludes, might have been easily explained. From the sequel of this inquiry, however, it will appear probable, that his ship's head was at the time near the *west point* of the compass; and that the observations were accurate.

[1] Dampier's Voyages, vol. iii. p. 68, 69.

In the introduction to the astronomical observations made by Mr Wales, in his second voyage with Captain Cook, are the following remarks.

" In the English channel, the extremes of the observed variation were from 19½° to 25°; and all the way to the Cape of Good Hope, I frequently observed differences nearly as great, without being able any way to account for them, *the difference in the situation being by no means sufficient.* These irregularities continued after leaving the Cape, which at length put me on examining into the circumstances under which they were made. In the examination it soon appeared, that when most of these observations were made, wherein the greatest west variation had happened, *the ship's head was north and easterly;* and that when those, where it was least, had been observed, it was *south and westerly.* I mentioned this to Captain Cook and some of the officers, who did not at first seem to think much of it; but as opportunities happened, some observations were made under those circumstances; and very much contributed to confirm my suspicions; and throughout the whole voyage I had great reason to believe, that variations observed with the *ship's head in different positions, and even in different parts of her, will differ very materially from one another;* and much more will observations observed on board different ships, which I now find fully verified, on comparing those made on board the Adventure, with my own made about the same time in the Resolution."

In the Introduction to Captain Cook's third voyage, Mr Wales notices a variety of cases wherein differences were found in the variation of the compass. These cases are as follows:

1st, Putting a ship's head a contrary way; differences 3° to 6°, and even 10°.

2d, At different times of the same day; difference from 3° to 7°.

3d, Being under sail, and at anchor in a roadstead; difference 5°.

4th, On board different ships, 3° to 5°.

5th, Near the same place, at different times of the voyage, 4° and 5°, or upwards.

6th, In different compasses, 3° to 6°.[1]

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[1] Captain Flinders makes the following remark on these differences: "That the variation should be different on changing the ship's head, or the place of the compasses, and also on board different ships, is perfectly reconcileable to the explanation I have given; but that it should vary so much at different times of the same day, or year—when under sail and at anchor, or even in different compasses—much surprised me, if all other circumstances were the same. I was

The following Table, containing a few of the instances here mentioned, is drawn up from the different observations on the variation made by Mr Wales and Captain Cook, in their voyages of discovery. It is indeed somewhat extraordinary, when we consider the ardent zeal manifested by those gentlemen in inquiring minutely into every subject connected with their voyage, that they should not have examined the differences of variation with more attention. A very little additional observation could not have failed to point out to the sagacious Cook the true cause of these incongruities; although the merit of this most illustrious of navigators could scarcely have been enhanced by the discovery.

therefore induced to examine the instances quoted under each case; and found reason to believe, not only the direction of the head was changed in most, if not all of those where great differences had been observed, but also that the differences themselves were conformable to what had taken place upon the binacle of the Investigator." Vol. ii. p. 523.

Observations on the Differences found in the Variation, according to the Point of the Compass the Ship's Head was on at the Time of Observation. By Captain Cook and Mr Wales.

Time.	Lat.	Long.	Ship's Head.	Var.	Difference.	Remarks.
1773.	South.	East.				
Mar. 11.	58° 55½′	131° 38′	North	8° 24′W	3° 22′	
..	..	..	South	11 46		
..	..	..	Southerly	11 57½	5 39	
..	..	..	Northerly	6 18½		
13.	58 44½	133 50	S S E	7 37	2 58	
..	..	..	N N E	10 35		
June 22.	44 37½	196 30	East	9 3¼E	2 17¾	
23.	..	197 53	South	11 21		
1774.						
Jan. 24.	65 15⅝	250 55	S S E	15 48	9 39	Mean of several Obs. taken by Capt. Cook.
..	..	..	S W *b* W	25 27		
..	..	..	S S E	19 38		
June 23.	20 24	186 52	W S W	11 40	2 18	
24.	20 12	186 10	E S E	9 22		
25.	26 26	185 42	W S W	12 6½	1 1	
26.	26 15	185 49	E S E	11 5½		

The very intelligent Captain Phipps, afterwards Lord Mulgrave, in the account of his Voyage towards the North Pole, makes the following remarks on this subject.

" The variation of the compass, always an interesting object to navigators and philosophers, became peculiarly so in this voyage, from the near approach to the pole. Many theories that had been proposed on this subject, were to be brought to the test of observations made in high latitudes, by which alone their fallacy or utility could be discovered. They, of course, engaged much of my attention, and gave me the fullest opportunity of experiencing with regret, the many imperfections of what is called the azimuth compass.

" This instrument, though sufficiently accurate to enable us to observe the variations, so as to steer the ship without any material error, with the precaution of always using the same compass by which they are taken, is far from being of such a construction as to give the variation with that degree of precision which should attend experiments on which a theory is to be founded, or by which it is to be tried. The observations taken in this voyage will fully evince this, by their great variations from one another in very short intervals of time; nor is this disagreement of successive observations peculiar to the high latitudes, and to be imputed to a near approach to the pole, as I found it to take place even upon the English coast."

It is clear from the above passage, that Captain Phipps did not entertain any idea that the direction of the ship's head had any effect on the variation. He considered the imperfection of the compass as the *sole* cause of the observed discordances.

The following Table contains the mean results of all the observations made on the variation during Captain Phipp's voyage. They will be found to correspond, in several instances, with my observations made in those seas in 1814; and when they do not agree, we may perhaps infer, that the differences arise more from the difference of our courses, than from any change in the real variation itself, or from the inaccuracy of the compasses.

Observations on the Variation of the Compass, made in a Voyage towards the North Pole in 1773, by Captain Phipps.

Latitude.	Longitude.	Ship's Head.	Variation.	Difference	Remarks.
52° 20′ N			16° 55′ W		Weather fine,
60 20	1° 7′ W		21 53	4° 23′	water smooth.
60 20	0 39		22 58		
60 20	0 39		23 46		
60 20	0 39		26 16		
62 30	0 4		19 22	3 56	Fresh breezes.
68 12	0 37		23 18		
73 55	7 15 E.		17 9	9 35	
74 10	8 36		7 47		Light airs.
74 20	9 43		17 22		
78 2	7 50		10 10	3 23	
78 2	7 50		9 34		
78 2	7 50		12 36		
78 2	7 50		12 57		
78 22	9 8		14 55		
79 50	10 2		20 58	8 11	
80 18	12 12		12 47		
79 44	9 51		18 57	5 20	
68 46	3 24		19 33		At Smeerenberg.
68 47	3 24		24 17		
65 47	2 27		26 55	4 41	Calm & smooth.
65 4	2 21		22 14		
63 45	2 16		25 46		
52 47	1 30		20 47		

Differences of variation were observed on board La Recherche, whilst in search of the unfortunate La Perouse, similar to those already mentioned.

"Monsieur Beautemps Beaupré, surveyor to the expedition, found so much uncertainty in compass bearings, that he abandoned, as far as was possible, the use of them, substituting the sun's azimuth and angular distance from some one point, and measuring the angles from that point to other objects." He says of the compass; "We found by a great number of observations, but principally by the difference between the bearings of points set with each other from opposite directions, that no confidence could be had in bearings taken with the compass from the deck of a large vessel. We also remarked, that the compass shewed *differences of several degrees in variations at sea, though observed with the greatest care, and within the space of a few minutes.*"[1]

Though we cannot imagine Captain Vancouver was ignorant of the important remarks made respecting the variation by former navigators, particularly those made by Mr Wales already cited, we do not find him adverting to that subject after he cleared the English Channel.

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[1] Flinders, vol. ii. p. 525.

He says, (vol. i. p. 6.) "The error in the reckoning, amounting almost to a degree, (of longitude,) seemed most likely to have been occasioned by our not having made sufficient allowance for the variation of the compass in our first sailing; as, instead of allowing from 22° to 25°, which was what we esteemed the variation, our observations for ascertaining this fact, when the ship was sufficiently steady, shewed the variation to be 28° and 29½° westerly." This remark gives no ground to suspect Vancouver attributed the error in his reckoning to any change of the variation caused by a change in the ship's direction; on the contrary, it is evident he was not aware of this fact; and this is to be regretted, as the accuracy of his surveys would have been greater had this circumstance been taken into account.

The following Table, comprehending most of the variations obtained during Vancouver's voyage, may not only be useful in the further developement of this subject, but to navigators who may not possess this expensive voyage itself.

The direction of the ship's head not being mentioned at the time of observation, we have reason to suppose it was changed where the differences were observed; which I have noted in the column "Difference."

Table of Variations observed in a Voyage round the World, in 1791, 1792, 1793, 1794, and 1795, by Captain Vancouver, in his Majesty's Ship Discovery.

Time.	Lat.	Long.	Var.	Diff.	Remarks.
	° ′	° ′	° ′		
1791	42 34 N	12 13 W	26 29 W		
	28 29	16 17	16 38		At Teneriffe.
	27 5	16 52	17 34		
	S	E	25 40		At the C. of Good Hope
	39 45	37 52	32 59		
	38 19	51 21	32 47		
	38 15	69 33	25 52		
	38 45	73 27	23 36		
	36 45	105 47	14 10		
	35 5	118 14	5 20		King George's Sound.
	44 46	165 48	14 16 E		Dusky Bay.
	27 34	215 58	5 40		
1792	17 30	210 24	6 12		Otaheite.
	21 17	202 10	7 50		Whyteete Bay.
	24 43 N	209 6	4 5		
	39 27	236 25	16 0		
	40 32	235 28	16 0		
	41 36	235 58	16 0		
	44 42	235 53	18 0		
	48 49	236 19	21 30		Port Discovery.
	48 2½	237 27	19 36		
	47 30	237 46	19 30		
	48 53½	237 33	19 26		
	50 11	235 21	19 16	3 16	Taken on board, which differed from 17° to 23°.
			16 0		
	50 23	234 32	19 0	1 45	Thurlow's Island.
	50 35	232 57	20 45		Sandy Island.
	51 32	232 3	17 7	3 38	
	49 34	233 21	18 22		Nootka Sound.
	36 36	238 26	12 22		Monterry Observatory.
1793	32 30	239 14	12 0		
	19 53	224 19	5 16		
	19 28	203 58	7 47		Karakakooa.
	30 35	197 42	13 46		
	53 11	231 3	20 41	4 37	
	55 16	230 16½	25 18		

Table continued.

Time.	Lat.	Long.	Var.	Diff.	Remarks.
	° ′	° ′	° ′		
1793	58 15 N	228 24 E	28 30 E	2 3	
	56 20	226 35	26 27		
	34 24	240 43	10 15		
1794	61 17	210 53	29 30		
	60 16	213 22	28 30		
	58 12	223 55	30 0		
1795	5 33	273 5½	7 45		
	2 3 S	L. not noted	7 45		
	4 15	265 15	9 7		
	12 45	260 32	4 55		
	19 24	253 45	2 45		
	33 56	280 1	9 15		
	33 1½	288 29	14 49		
	56 57	293 39	23 0		
	36 45	324 43	6 0		
	in the Line				
	0 0	21 35W	9 20W		
	51 2	20 6	22 0		

It was reserved for the acute and penetrating genius of Flinders, to explain the true cause producing these discordances in the variation of the compass observed on board ship, as well as occasionally on shore. That experienced navigator, at an early period of his last voyage, found such unaccountable differences in the quantity of variation deduced from different observations he occasionally made, as determined him on instituting an inquiry into their causes, and if possible to ascertain the laws by which they were regulated.

“ Several instances,” he observes, “ have been mentioned in the course of this voyage, where the compass shewed a different variation on being removed from one part of the ship to another. Thus observations on the binnacle gave 29½° off the Start, where the true variation was about 25½° west; whilst others taken upon the booms before the main mast, sixty-eight miles lower down Channel, gave only 24°; and in the experiments made with five compasses, the mean variation at the binnacle was 4° 37′ greater than on the booms.

"It soon became evident, however, that keeping the compass to one spot, was not sufficient alone to ensure accuracy: a change in the direction of the ship's head was also found to make a difference in the needle; and it was necessary to ascertain the nature and proportional quantity of this difference, before a remedy could be applied. This inquiry was attended with many difficulties; and no satisfactory conclusion could be drawn, until a great variety of observations were collected. It then appeared, that when the ship's head was on the *east side* of the meridian, the differences were mostly one way, and when on the *west side* they were the contrary; whence I judged, that the iron in the ship had an attraction on the needle, and drew it forward. But there was this remarkable distinction: in the northern hemisphere, it was the north end of the needle which was attracted, and in the southern hemisphere it was the south end. In the instance off the Start before cited, when the ship's head was *west*, the north end of the needle had been drawn forward, or to the left of north, nearly 4°, and the west variation thereby increased to 29½°; with the head at *east*, it would be drawn to the right of its natural position, and the variation diminished to about 21½°; but at *north*, the attraction in the ship was in the same line with the magnetic poles of the earth, and would therefore produce no change. The same thing took place at *south;* for the two attractions were still in the same continued line, though in opposite sides of the compass; and throughout the voyage, I found the variation, taken with the head at north and south, agreed very nearly in themselves, and with the observations on shore near the same place, when such observations were not affected by local attractions."

The following Table contains a few of the instances, where the change in the variation was observed by Captain Flinders. The remainder made to ascertain the amount of this change in the variation, will be inserted subsequently.

Table of Variations observed in a Voyage of Discovery to Terra Australis, in 1801, 1802, *and* 1803, *by Captain Flinders, in his Majesty's Ship Investigator.*

Time.	Lat.	Long.	Ship's Head.	Var.	Diff.	Remarks.
	° ′	° ′		° ′		
1801	49 50 N	5 52W	West.	29 34W		Off the Start.
	49 48	4 2		29 30		
	5 38	16 50	S E *b* S	12 18		Off the African coast.
	2 21	14 15	W S W	14 54		
1802	35 48 S	139 3 E	W *b* S	5 11 E	° ′ 6 1	Encounter Bay.
	35 49	139 12	S E	0 50W		
	36 42	139 50	S S E ½ E	1 25 E		
	37 30	139 40	South.	4 8	1 29	Off Cape Buffon.
	37 50	139 41	S E *b* S	2 39		
	37 56	139 41	S S E	2 2		
	37 55	139 48	N E	2 2		
	39 38	144 40	W S W.	11 52	3 53	Bass Straits.
	39 38	144 1	South.	7 59		
	38 36	144 20	N E *b* E ½ E	3 41	3 7	
	38 38	144 30	N N E ½ E	6 48		
	34 5	123 9	W S W	0 54W	5 16	At anchor in Goose Bay.
	34 4	123 10	East.	6 10		
	34 5	135 9	S E *b* E	1 33	5 28	
	34 6	135 9	S W *b* W	3 56 E		
	34 7	137 19	S W *b* S	4 48	4 48	Off Point Pearce.
	34 16	137 16	E *b* N	0 10W		
	34 22	137 21	S E	0 35	2 40	
	34 42	137 14	S S W	3 15		
	34 36	138 18	S *b* W	5 22	2 59	At anchor off St Vincent.
			S E	2 27W		
	32 40	125 25	E *b* N	7 25	2 49	Off South Cape.
	32 30	125 40	South.	4 26		
	32 32	125 54	N E	6 13	1 55	
	32 24	126 23	S *b* E	4 18		
	32 7	128 1	E *b* N	6 4	2 56	
	32 17	128 2	S *b* E	3 8		
	32 15	132 39	E *b* N	2 49	3 8	Nuyt's Archipelago.
	32 23	132 56	S ½ W	0 19		

There not being any other *published* observations illustrative of this change of the variation that I have been fortunate enough to meet with, I shall now take the liberty of inserting a few I have made on the same subject.

I first noticed the error in the variation of the compass, caused by the change in the position of the ship's head, on the 21st of September 1811. His Majesty's ship Sybille[1] was proceeding to the Cove of Cork, and the old head of Kinsale was just seen before dark. Not having sufficient day-light to carry the ship in, it was judged expedient to lie off and on, keeping the light NE until day-light the following morning. During the night, wind WSW, I frequently observed, that when standing in NW *b* W and NW before we tacked, with the light bearing NE immediately after tacking, when the head was south and S by E, the light only bore N E by N. At the moment, this difference in the bearings was reckoned an effect of strong lee currents, and more sail was put on the ship to keep her to windward; but when we again tacked and stood in for the light, those fears were removed, for the light was found to be considerably to eastward of N E.

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[1] I had some months before been appointed to the Sybille, after my return from the East Indies, where I had remained since 1793.

The following Table will shew this difference more distinctly.

Table, shewing the Difference in the Bearings of Kinsale Light, with the Head of his Majesty's Ship Sybille, on different points of the Compass, *September* 21. 1811.

Object.	Before Tacking.		After Tacking.	
	Bearings.	Ship's Head.	Bearings.	Ship's Head.
Kinsale	N E.	N W *b* W.	N E *b* N.	S *b* E.
Light . .	N E.	W N W.	N E *b* N.	South.

Subsequent to the above period, I had occasion to make similar observations in going up and coming down the English channel, without being able in any way to account for them, until a paper was sent Captain Upton by the Admiralty, containing a series of remarks and observations of a like nature, with a detailed account of the local causes from which such differences arose; and giving directions for observing the variation, by amplitude and azimuth, as often as circumstances would admit.

Since then I have considered this subject with some attention, and, from the observations I have made, am enabled to say, that it is of the highest importance to navigators that it should be accurately known, and always attended to, in their computations.

In the two following Tables, will be found some of the most unexceptionable observations made respecting the variation during the time I was in the Sybille. The first Table contains those made in two cruizes from St John's, Newfoundland. In the other, are those made during a cruize from England to East Greenland, in company with his Majesty's ship Carolina, and which are delineated in the chart prefixed to this work. While there, my attention was particularly drawn to this subject, in order to ascertain how far the laws of magnetism, influenced by local attraction on board ship in the northern hemisphere, corresponded with those in the southern. On comparison, it will be found, that in both hemispheres the magnetic needle is equally influenced by a local attraction: causing a change or error in the variation, of a greater or less quantity, according as the direction of the ship's head is more or less removed from the magnetic meridian.

A Table shewing the Variation of the Compass, as observed on board his Majesty's Ship Sybille, in 1813, on a cruize from St John's, Newfoundland.

Year, Mon. and Day.	A. M. or P. M.	Lat. North.	Long. West.	By what.	Sun's Altitude corrected for Dip, &c.	Magnetic Azimuth or Amplitude.	By whom taken.	Ship's head.	Variation West.	Difference.	Remarks, &c.
1813 Aug		° ′ ″	° ′ ″		° ′ ″	° ′ ″			° ′ ″	° ′ ″	
5	A. M.	52 0 0	52 0 0	Azim.	11 20 0	E 28 52 40 S	Lieut. Phillips.	WNW	42 10 55	6 6 55	Good sights.
5	P. M.	52 10 0	52 20 0	—	10 19 0	N 39 30 0 W	Mr Bain.	NNW	36 6 0		Ditto.
7	A. M.	52 25 0	52 50 0	—	25 27 10	S 44 50 0 E	—	WNW	38 18 30		Much motion.
8	A. M.	51 35 0	54 15 0	—	6 0 0	E 20 41 0 S	—	WSW	39 22 5		Close in with White Cape.
22	P. M.	48 46 0	51 25 0	—	8 55 15	N 48 0 0 W	—	W½N	34 20 15		Some motion.
23	A. M.	48 42 0	52 14 0	—	19 30 0	S 49 30 20 E	—	NW *b* W	35 50 10		Good sights.
27	A. M.	47 43 30	52 54 15	—	25 32 57	S 50 17 10 E	—		26 10 5		Taken on shore at Harb. Grace, Newfoundland.
Sept											
8	A. M.	47 33 30	52 25 15	—	9 4 12	S 55 17 0 E	—	W½S	33 24 15	6 23 45	St John's Harbour.
8	A. M.	47 33 30	52 25 15	—	18 24 0	S 51 15 0 E	—		26 50 30		Taken on shore.
14	P. M.	48 10 0	52 15 0	—	17 5 50	N 70 18 0 W	—	NW½W	34 18 45	5 53 15	Bacaliu Isl. NNW 7 miles.
14	P. M.	48 10 0	52 15 0	—	11 35 50	N 69 37 0 W	—	S *b* E	28 25 30		Bacaliu Isl. do.; tacked.
20	P. M.	45 13 0	53 21 0	—	11 3 0	N 77 22 0 W	—	W½N	22 21 45		Compass at the mainmast.
24	A. M.	43 36 0	59 10 0	—	19 12 0	S 50 0 0 E	—	NW	20 10 30	7 45 45	Ship steady.—Good.
Aug											
1	P. M.	44 21 0	62 20 0	—	9 45 0	S 88 0 0 W	—	SE	12 24 45		Some motion.
18	P. M.	41 22 0	47 41 0	—	7 54 0	S 87 0 0 W	—	E *b* S	17 26 30		Very good.

Table continued.

Year, Mon. and Day.	A. M. or P. M.	Lat. North.	Long. West.	By what.	Sun's Altitude corrected for Dip, &c.	Magnetic Azimuth or Amplitude.	By whom taken.	Ship's head.	Variation West.	Difference.	Remarks, &c.
		° ′ ″	° ′ ″		° ′ ″	° ′ ″			° ′ ″	° ′ ″	
Aug											
19	P. M.	40 54 0	45 15 0	Azim.	13 44 0	S 82 30 0 W	Mr Bain.	SE *b* S	19 10 45		Good.
19	P. M.	40 50 0	45 10 0	Ampl.		W 7 0 0 N	—	SE *b* S	19 20 0		Good.
20	A. M.	40 47 0	44 25 0	Azim.	4 20 0	E 37 10 0 S	—	SE *b* S	19 36 0	5 37 43	Good.
22	A. M.	40 20 0	40 41 0	—	7 13 15	E 46 39 0 S	—	W *b* S	25 13 43		Good.
25	A. M.	40 3 0	42 9 0	—	22 10 0	E 68 20 0 S	—	N *b* W	23 46 10	5 19 30	Good.
25	P. M.	39 48 0	42 4 0	—	16 43 10	S 76 0 0 W	—	SE *b* E	18 27 30		Good.
26	A. M.	40 1 0	42 9 0	Ampl.		E 35 0 0 S	—	NE	18 43 0	1 19 45	Very good.
26	P. M.	40 16 0	42 20 0	Azim.	12 27 0	S 81 30 0 W	—	N	20 2 45		Very good.
30	A. M.	41 2 0	43 32 0	—	10 3 15	S 41 0 0 E	—	S *b* E½E	20 41 30		Some motion.
Nov.											
2	A. M.	40 42 0	43 28 0	Ampl.		E 39 0 0 S	—	SE *b* E	19 57 0	1 32 0	Good.
3	A. M.	41 2 0	42 33 0	—		E 41 22 0 S	—	N *b* E½E	21 17 10		Good.
3	A. M.	41 4 0	42 33 0	Azim.	9 29 10	E 51 0 0 S	—	N *b* E½E	21 29 0		Good.
4	P. M.	40 58 0	43 14 0	—	11 39 15	S 74 30 0 W	—	E *b* N	17 6 30	5 28 0	Good.
5	A. M.	41 52 0	44 14 0	—	10 53 0	S 34 40 0 E	—	NW *b* N	22 34 30		Good.
8	P. M.	41 40 0	44 31 0	—	11 52 0	S 79 45 0 W	—	W½N	25 6 10		Good.
10	A. M.	41 23 0	47 55 0	—	10 20 15	S 29 30 0 E	—	WNW	26 29 15	5 40 30	Good.
10	P. M.	41 36 0	47 54 0	—	10 48 20	S 75 45 0 W	—	N *b* E½E	20 39 45		Good.

A Table shewing the Variation of the Compass, as observed on board his Majesty's Ship Sybille, in 1814, in a Cruize to East Greenland.

Mon. Day, and Year.	A. M. or P. M.	Lat.	Long.	Sun's Altitude corrected.	Magnetic Amplitude.	Ship's Head.	Var.	Difference	Remarks.
1814 May		North ° ′	East ° ′	° ′	° ′		West ° ′	° ′	
11	A. M.	53 38	2 22	24 12	S 61 15 E	NW	24 49		Good.
12	A. M.	54 34	2 37	23 59	S 61 20 E	NW *b* N	26 18		Ditto.
16	A. M.	57 2	3 37	24 1	S 66 45 E	NNE	21 35	5 25	Ditto.
16	P. M.	57 53	2 21	21 32	N 62 50 W	NW ¼ W	27 0		Ditto.
24	P. M.	60 27	1 58	15 21	N 50 15 W	NE *b* E	24 49		Ditto.
25	A. M.	60 27	2 0	27 6	S 60 40 E	N *b* W	24 4	3 50	Ditto.
26	P. M.	60 52	2 50	18 33	N 58 40 W	NE	20 14		Ditto.
June									
2	P. M.	73 14	18 10	17 50	N 60 30 W	NE *b* N	11 35		Good; sounded 100 fathoms line; mud.
4	P. M.	74 27	19 58	19 9	N 60 30 W	WSW	14 28		Not very good.
8	P. M.	73 59	29 55	18 20	N 66 15 W	NE *b* N	4 55	6 25	Good. } Ship put on other tack.
8	P. M.	74 0	29 52	15 32	N 48 40 W	WSW	11 20		Ditto.
13	P. M.	71 10	27 10	8 52	N 25 0 W	SW ½ S	13 10		Ditto; North Cape NW *b* W 5 leagues.
18	P. M.	75 22	18 21	15 2	N 37 50 W	N *b* E	16 12		Ditto; surrounded with ice.
26	P. M.	78 11	6 55	20 38	N 55 0 W	ESE	19 6		Ditto.

Table continued.

Mon. Day, and Year.	A. M. or P. M.	Lat.	Long.	Sun's Altitude corrected.	Magnetic Amplitude.	Ship's Head.	Var.	Difference	Remarks.
1814		North	East				West		
July		° ′	° ′	° ′	° ′		° ′	° ′	
3	A. M.	72 53	21 21	17 47	S 78 40 E	SSE	9 22		Good.
22	P. M.	70 27	10 38	17 14	N 61 30W	ESE	16 6	10 38	Some motion.
Aug.									
1	P. M.	68 58	10 25	15 26	N 52 40W	W½N	26 42		Good.
2	A. M.	68 33	9 10	13 40	S 79 32 E	W *b* S½S	25 14		Ditto.
2	P. M.	68 20	8 59	14 32	N 55 30W	SSW	22 42	7 37	All good, the evening very fine; the ship was purposely put round in this manner.
2	P. M.	68 20	8 59	13 50	N 51 15W	West	25 11		
2	P. M.	68 20	8 59	12 57	N 56 20W	NE *b* N	17 34		
8	P. M.	67 37	3 20	15 6	N 57 35W	South	26 43		Good.
11	A. M.	62 10	0 20	13 48	S 65 55 E	W *b* N	31 15		Ditto; Long. by ⊙ ☾ and chronometer.
			West						
14	P. M.	61 23	0 6	20 18	S 52 30 E	W½S	30 36	5 8	Ditto.
14	P. M.	60 57	0 23	15 47	N 60 0W	ESE	25 28		NE end of Shetland S 11° E 5 or 6 leagues.
14	P. M.	60 57	0 10	3 0	N 34 30W	W *b* S	30 40	10 25	NE end of Shetland S 48° W 4 or 5 leagues.
15	P. M.	60 25	0 28	11 52	N 62 0W	ESE	20 15	10 17	Outer Skerry SSW 2 miles.
17	. M.	59 7		13 23	N 55 30W	W *b* S	30 32		Lamb Head W½S 6 miles.
17	P. M.	59 6		4 54	N 41 20W	WSW	30 26		Very good; Lamb Head W *b* S 4 miles.

Table continued.

Mon. Day, and Year.	A. M. or P. M.	Lat.	Long.	Sun's Altitude corrected.	Magnetic Amplitude.	Ship's Head.	Var.	Difference	Remarks.
1814 Sept.		North ° ′	West ° ′	° ′	° ′		West ° ′	° ′	
2	A. M.	58 17	8 31	6 58	S 61 15 E	NW	33 1	3 30	St Kilda Isl. S¾W 8 or 9 leagues; no bottom, 180 f.
2	A. M.	58 17	8 31	8 26	S 62 17 E	North	29 31		Both sights good, weather fine, and the ship was put on these courses purposely.
2	P. M.	58 2	8 56	9 52	N 57 15W	SW	32 3		Very good; St Kilda SE½S 6 leagues.
2	P. M.	57 55	9 2	Amp.	W48 30 N	SW *b* W	33 20		Good.
9	P. M.	50 51	9 32	8 13	N 62 10W	NW	29 36	6 44	Ditto.
10	P. M.	50 39	8 34	15 37	S 56 0 E	SSE	22 52		Ditto.
12	A. M.	50 30	6 26	11 13	S 60 30 E	NE *b* E	22 50		Ditto.
12	P. M.	50 0	6 27	5 16	N 68 0W	E*b*N½N	21 55		Ditto.
13	P. M.	49 59	6 22	8 12	N 71 30W	SE *b* E	22 30	4 36	St Mary's Castle E 51° S; St Agnes lighth. W 54° S
14	A. M.	49 56		19 5	S 46 30 E		27 16		Observed at St Agnes lighth. with artificial horizon
14	P. M.			Amp.	N 57 0W		27 31		Obs. at St Mary's flag staff; both sides excellent.
15	P. M.				N 58 0W	SW	27 13	6 15	St Agnes lighthouse N½E 3 leagues; good.
16	A. M.	49 3	6 18		S 73 0 E	East	20 58		
17	P. M.	50 10	4 4	7 50	N 69 20W	SSW	26 26	5 26	Eddystone WNW 7 miles; ☉ ☾ taken at same time gave 4° 4′ west longitude.
18	P. M.	50 30	2 0	10 11	N 79 10W	E *b* N	20 14	6 6	St Aldin's Head NE *b* N½N 5 miles; good.
18	P. M.	50 30	2 0	Amp.	N 62 30W	SSW	26 20	6 10	St Aldin's Head NE *b* N 2 miles; good.
20	P. M.	50 31			N 54 30W	West	32 30		Start Point NW *b* W 5 leagues; good.

From the many observations we have now given respecting the change of the variation, caused by a change in the direction of the ship, relatively to the meridian; it is presumed that none will be disposed to doubt of such a change really taking place: And I shall therefore proceed to notice the effects of this change on navigation.

No intelligent seaman could possibly avoid observing the difference between the course he steered up the English Channel, and the opposite course steered going down Channel. This difference in the courses is produced by the local attraction of the ship, acting on the magnetic needle in a contrary direction; for it is evident, that if 27° or 28° of westerly variation are allowed in going up Channel, when the ship's head is E or E by S there must be 5° of error in the reckoning; for with the head in this direction, only 22° or 23° of variation will be found. In going down Channel when the head is at W. or W *b* N. and only allowing 27° or 28° of variation, there also must be 5° of error in the reckoning; because, with the head in that direction, the variation amounts to 32° or 33°. When the head is at *east,* the local attraction of the ship draws the north end of the needle *eastward;* when the head is at west, it is drawn *westward;* and it is this attraction which requires a different course to be steered up, from the opposite one, which was steered down Channel.

On the 17th January 1814, his Majesty's ship Sybille sailed from Plymouth to Portsmouth with a naval transport, whose name I forget, under convoy. About six in the evening, we passed the Start, bearing north distant 2 or 3 miles, and as the night was fine, with a fresh breeze from the WNW. a course was shaped E½S. to pass the Portland lights at 5 or 6 miles distance, which I expected to see, from our rate of going, before 12 o'clock. By half-past 11, the ship had nearly run, making every allowance for tides, &c. the distance, but no lights were to be seen from the deck; and becoming anxious, I ordered a man to the mast head to look out for them. In going up, he descried the lights from the main top, and made us acquainted with their bearing, which was nearly on the beam of the ship, at a distance not less than 12 or 13 miles: Sail was immediately shortened, and the ship hove to.

On the 16th of March 1814, his Majesty's ship Sybille sailed from Spithead, through the Needles, for Plymouth. About eight in the morning, the ship was outside the Needles point, and a course was shaped W½N. to pass the Start at a moderate distance; which, with the strong breeze we had, I expected to do by 4 o'clock in the afternoon. The weather hazy, with the wind from the eastward, we soon lost sight of the coast; but being a little surprised it was not again seen at the time expected, I altered the course to WNW. and NW *b* W. when shortly after the Start was seen. Had we continued on our former course, we would have passed the Start at 10 or 12 miles distance.

In both cases, the error in the reckoning, caused by the error or change in the variation, will be more clearly illustrated by the following Tables.

Table shewing the Error in the Reckoning, caused by the change in the Variation, in a run from the Start to Portland Lights, on the night of January 27, 1814.

	Course.	Dist.	Diff. Lat.	Diff. Long.
	°	′	′	′
True course and distance between the Start and Portland	N 65 E	50	21.1	69.9
Variation allowed	28			
Supposed course steered by compass	E 3 S			
True variation, with head east .	23			
True course steered	N 70 E	50	17.0	74.0
Error in reckoning caused by change in variation N. B. The ship is all this difference to the SE. of her supposed situation.			4.1	4.1

Table shewing the Error in the Reckoning caused by the change in the Variation, in a run from the Needles to the Start, March 17, 1814.

	Course.	Dist.	Diff. Lat.	Diff. Long.
	°	′	′ ″	′ ″
Course and distance between the Needles and Start	W69 S	83	29 7	122 0
Variation allowed	28			
Supposed course steered by compass	W 7 N			
True variation, with head west	33			
True course steered	W64 S	83	36 4	116 0
Error in reckoning, caused by change in variation N.B. The ship is all this difference to the SE. of her supposed situation.			6 7	6 0

Let us suppose, that in a ship bound down Channel at dark, St Catherine's Point bore N. 3 or 4 miles, with the wind ENE.: she steers W *b* N. during the night, and at daylight next morning, the Start is observed bearing N. 3 or 4 miles distance. Let us farther suppose, that at this instant the wind suddenly shifts to the WSW. and begins to blow hard, with thick rainy weather, which determines the Captain to bear up for St Helens. As a W *b* N course carried him to the Start, he would naturally resolve to steer the opposite one up, namely E *b* S. On his supposed approach to the Isle of Wight, he is extremely anxious to see the land, and the weather continuing thick, does not like to alter his course, being satisfied the one he was steering will take him near enough shore. But after the distance is run, no land is to be seen; and as, perhaps, it is flood, he immediately hauls in shore, but it is too late; for being 15 miles to the south, and 6 miles to the east of his reckoning, he finds himself, by the time he sees the land, to eastward of Dunnose; and the gale continuing, cannot possibly fetch his port. This fictitious case is often realised, and all navigators are aware of the consequences.

Now, this mistake in the reckoning is caused by not allowing for the change in the variation; for if the course W *b* N. steered down Channel (W. 21° 45′ corrected for 33 variation) led him off the Start 3 or 4 miles, the opposite one up E *b* S. (E. 11° 45′ N. corrected for 23° variation), must necessarily have been 10° too southerly, and would therefore cause an error in his reckoning 15 miles to the south, and 6 miles to the east.

The following Table illustrates this supposed case.

Table shewing the Error in the Reckoning between St Catherine's Point and the Start, and the Start and St Catherine's, by steering opposite points of the compass.

	Course.		Dist.	Diff. Lat.		Diff. Long.	
	0	′	′	′	″	′	″
Course steered down by compass	W11	15 N					
True variation, with head W *b* N.	33	0					
True course corrected for variation	S 21	45 S	90	33	7	83	4
Course steered up by compass .	E 11	15 S					
True variation, with head E *b* S.	23	0					
True course corrected for variation	E 11	45 N	90	18	7	88	0
Error SE. of the reckoning, by steering opposite points down and up Channel 90 miles . . .				15	0	4	6

During the late war, experience taught navigators, that the steering homewards the opposite course, which led them to certain ports on the coasts of France, Spain, and Portugal, was fraught with the most alarming consequences. Hence the knowledge that a different course was required to be steered in coming back, from the opposite one made use of in going to any of these places, was universal; though I am not aware that the cause of this difference was very generally known; as every error that creeps into the reckoning of the navigator is too often ascribed to the effects of currents.

A ship, for instance, going from Plymouth to Cape Finisterre, will every day at noon find herself considerably to southward and eastward of the dead reckoning; but this difference is immediately concluded to be the effect of currents setting round Cape Clear into the Bay of Biscay; and it is never once imagined that the reckoning can be affected by an error in the allowance made for variation. I am, indeed, very far from saying, that no current of this nature exists; but I will venture to affirm, that the error in the reckoning is greatly increased by not attending to the change in the variation. Let us exemplify this.

The true course from Plymouth to Cape Finisterre is nearly S. 26° W.; distance 501 miles. The variation generally allowed is 28°, which makes the course to be steered by compass, S 54° W. or SW ¾ W. Now, with the head in this direction, the variation amounts to 31°, which makes the true course corrected for variation S. 23° W. and not S. 26° W.; making a difference of 12 miles to the south in the latitude, and 35 miles to the east in the longitude.

The same error in the reckoning will be experienced coming from Cape Finisterre to Plymouth, if the change in the variation is not attended to; but with this difference, that with the head N. 54° E. the variation amounts only to 25°.

We know that the greater part of our merchant ships have no other means for ascertaining their longitude, than the course they steer, as ascertained by the log-line and half-minute glass; and hence it is no uncommon thing to fall in with very valuable ships 2°, 4°, 6°, and 8° out of their reckoning. Every captain of a man of war, who has been cruizing in the mouth of the Channel will bear testimony to this assertion.

Merchants seldom know the hazards their fortunes run, or insuring companies the losses they sustain from ignorance. One hundred pounds for a good chronometer, and a few pounds more per month to a man who understands its use, or can appreciate its value, and make lunar observations, is strenuously opposed as an unnecessary expence, abstracting too much from the profits of the voyage; and therefore we often see hundreds of thousands of pounds risked to mere chance. I once boarded a very fine rich West India ship bound to London. The first question I was asked —" How does the Start bear?" " The Start!" I replied. " Yes, the Start; we have been looking out for it all the morning." I inquired whether he had tried for soundings?—" No, he did not like to lose time." I then informed him of his true position, and that our chronometers made his longitude 14 west. The poor man was thunderstruck, and could only be convinced of his true situation by finding no soundings at 120 fathoms. The changes of variation are too nice a matter for such navigators; and the management of chronometers, and the taking of lunar observations, are altogether out of the question. The value of a good chronometer on board a ship is incalculable, and the advantage of verifying its results by lunar observations, gives the navigator that confidence in his true position, which must always insure him an expeditious passage. A Master so provided navigates his ship boldly by night as well as by day; whereas a navigator destitute of these advantages, is constantly in fear, and gropes his way as it were in the dark.

The best navigated ships, perhaps in the world, are those belonging to the East India Company. The liberality with which they are provided with good chronometers—the expertness to which the officers have attained in making lunar observations—the length of the voyage,—and the general fineness of the weather, all facilitate the finding the ship's true position. I have known a fleet of Indiamen anchor in Madras roads in the night, who had never seen the land from the time they left Madeira. It must indeed be acknowledged, that many of the Company's ships are annually lost; but the causes producing these fatal catastrophes have nothing to do with the nautical skill of the officers. The size of the ships—the deficiency of their crews during war—and an ill-directed spirit of economy, often renders the situation of the commanders less enviable than is generally supposed. Perhaps too, the error in the variation may sometimes occasion accidents in this, as well as other services. In the English Channel, where lunar observations and chronometrical results can seldom be obtained, several Indiamen unfortunately have been lost; and here if the winds and weather are both unfavourable, the dead reckoning is their only guidance. Now, from what has been said respecting the change in the variation in ships of war, may we not also suppose the same change takes place in Indiamen? They have many guns, and very frequently a great part of the cargo consists of iron. It is, therefore, very much to be wished, that the attention of those able and accurate navigators may be attracted to this subject, and that they would examine whether the error in the reckoning is produced by the change in the variation depending on the ship's course; and if the consequences resulting from this change are such as I have stated, a very great benefit must arise to the East India Company, as well as to the country, by their making proportional allowances. Every circumstance touching the safety of such valuable ships, or indeed of any ship, should, however minute, never be overlooked. The East India ships generally leave England in the dead of winter, and consequently experience many difficulties before clearing the Channel; and are frequently obliged, from stress of weather, to put back to port, after having advanced a good way to westward. In such a situation, with hard gales, thick weather, and a motley crew, it requires no common share of experience, skill, and fortitude, to manage those large, and sometimes overloaded vessels.—But neither skill, experience, nor fortitude, can guard against unknown errors; and if the navigator is steering, with all imaginable care, E *b* S up, because he steered W *b* N down, Channel, it is very evident, from what we have seen, that there will be nearly one point of error in his reckoning, without his knowledge. It is true, this error puts his ship to the S E of his reckoning, and may therefore be thought on the safe side, by keeping the ship from the English coast; but it may also lead to his utter destruction, by overrunning the port he intended to make.*

In the river St Lawrence, the change in the variation should be most particularly attended to, as it leads a ship, both in going up and coming down, on the coast most to be avoided.

On coming down that grand and magnificent river, May 1813, I found that it was necessary to steer a very different course from the opposite one made use of in going up, under very similar circumstances, a few days before. I noted the circumstance in my remark book, sent to the Lords of the Admiralty, on returning to England. And owing to that circumstance, and not having a copy, nor log-book to refer to, I cannot state from memory the courses steered, though I remember the difference to have exceeded one point; and that we had an eight and nine knot breeze both in going up and coming down, with the weather uncommonly fine, and every circumstance extremely favourable for making such remarks.

Subsequent to the above period, one of our ships of war, (the Zealous) had a very narrow escape in going up that river. The compasses in the binnacle were so much affected by local attractions, that, had the fog not cleared away at the moment it did, the ship must have run on shore, not far from Cape Chat: she was in 19 fathoms.

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* Many such instances too often occur. I am not sufficiently acquainted with all the circumstances under which the St Josef of 120 guns missed Portsmouth on her passage from Plymouth, to specify the precise cause which led to that event; but a more alarming, and distressing scene seldom or never occurred, short of shipwreck.

The gentleman from whom I had this information, could assign no other cause why the compasses were so influenced, except from the muskets placed round the mizen-mast; but on inquiry, I found they had been there during the former part of the voyage, and, consequently, this could not have been the primary cause, as the deviation must have been sooner perceived. I am therefore inclined to attribute the near approximation of the land as being the primary, and the local attraction of the ship as the secondary cause, acting on the magnetic needle with a compound force: all the compasses in the ship, when brought on deck, were alike affected.

I have great reason to believe, that the non-attendance to the changes of variation in the St Lawrence, and perhaps the vicinity, is one of the causes of the many losses that there happen.

Before quitting this subject, I may perhaps be permitted to notice an effect produced by the change of variation, but hitherto ascribed to very different causes. And there is not an officer, I will venture to say, in the British navy, but will bear testimony to the truth of the following statement.

When beating to windward, and obliged to tack pretty often, say in chace of an enemy, or endeavouring to gain a port, all seamen have remarked, that every time the ship was put about, the wind *came round* some points with the ship; so that, for instance, if the wind was at S, and lying W S W on one tack, the ship would only lie E *b* S or E on the other tack. At other times, we have been well pleased, under similar circumstances, to find the wind favour the ship a point or two on every tack; so that, if the wind was at N, and the ship lying WNW before tacking, she would lie NE *b* E and NE upon the other tack. It is not a change in the wind which produces these apparent differences, but it is wholly to be ascribed to the local attraction in the ship. When the head is westerly, the north end of the needle is drawn half this difference westward; when the head is easterly, it is drawn half the difference eastward.

I shall conclude this article on the change in the variation, as experienced in the Atlantic, with some observations on the currents of that ocean.

No navigator, cruising on the Atlantic, either eastward or westward, northward or southward, but must have found his ship, by chronometrical, or lunar results, considerably to the south-east of the dead reckoning. This difference is commonly ascribed to currents.

Captain Cook in the Resolution, and Mr Bayley in the Adventure, in their run to Madeira in 1772, experienced errors of this kind; the former nearly *one* degree, the latter 2° 12′.[1]

La Perouse in the Boussole, and De Langle in the Astrolabe, in 1785, found nearly the same difference in their run from Brest to Madeira;[2] and Vancouver, in 1791, detected *one* degree of error in his reckoning from England to the same place. But none of the abovementioned navigators appear to have assigned the true cause of this error getting into the reckoning except Vancouver, who rightly attributed it to his not having allowed a sufficiency of variation.[3]

That the error in the allowed variation, and *not* the effect of currents, was the cause of the error in the reckoning, may be shewn by calculating this run, and allowing for the error in the variation; when it will be found to agree with the error in the reckoning, as experienced by the abovementioned celebrated navigators.

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[1] Wales' Astronomical Observations, pp. 189, 311.

[2] La Perouse, vol. ii. pp. 182. 276.

[3] Vancouver's Voyage, vol. i. p. 6.

The following Table elucidates this subject in a clearer manner.

Table shewing the Error in the Reckoning caused by the change of Variation, in a run from the Lizard to Madeira.

	Bearings.	Dist.	Diff. Lat.	Diff. Long.
	° ′	′	° ′	° ′
Bearings and distance from Lizard to Madeira . . .	S 26 0W	1134	16 59	11 17
Variation allowed . . .	27 0			
Course steered by compass	S 53 0W			
True var. with head S 53° W	29 53			
True course corrected for error	S 23 7W	1134	17 26	9 50
Error in reckoning caused by error in variation			0 27	1 27

A ship coming to the Lizard from Madeira, will just have the same error in her reckoning as exhibited in the above Table; but with this difference, that with the head N 53° E, only 24° 53′ of variation will be found, instead of 29° 53′ with the head S 53° W.

A ship from St John's, Newfoundland, or from the southern part of the banks of Newfoundland, bound to England, by not making allowance for the changes of variation, will, by the time she reaches the Lizard, have an error of 64 miles in the latitude, and 198 miles in the longitude; that is, the ship will be this difference to the ESE of the reckoning.

The same error in the reckoning will be experienced going from the Lizard to St John's, by neglecting the allowance to be made in the variation; and would just be the same, were it possible for the ship to run the distance in ten hours instead of ten days.

Notwithstanding these facts, I know it will be extremely difficult to convince navigators in general of the fallacy of their opinions respecting currents constantly setting with great velocity to the SE in the Atlantic Ocean; and perhaps I may be scouted for the singularity of my conclusions. But, I presume, that one single fact established by experience, is stronger, and deserving of more credit than all the hypotheses founded on theory that can be brought together. I do not, however, deny the existence of currents in the Atlantic. Such an opinion would be perfectly absurd. But experience has taught me they are not nearly so powerful as generally imagined.

While cruizing in the Atlantic, I have proved this by many experiments, and cannot help acknowledging, that I have found them apparently setting as often the one way as the other. But this is not generally the case near the land. Local situations produce local currents; and there are few capes or promontories where currents are not more or less experienced. But if those capes or promontories are situated within the influence of *monsoons* or *trade winds*, the direction of the waters follows that of the winds. These currents are, however, very superficial; and we frequently observe two different currents in the same place, the upper part of the cable of a ship at anchor being sometimes carried one way, whilst the lower part is carried another. Even on the shores of the Florida Channel, the most remarkable in the world for its currents, a ship may pass the opposite way, by the revulsion of the water close in shore.

The *trade wind* which blows between the *coast of Africa* and *Brazil*, and the southerly winds which prevail on the coast of the former, (both of which phenomena are perhaps owing to the opposite rotation of the earth,) undoubtedly force along the surface of the ocean towards the coast of Brazil, which stopping its direct progress, it diverges towards the north and south. The greater part passes into the Gulf of Mexico, and hence by the famous gulf stream is again thrown into the Atlantic. A lesser portion passes west through the Straits of Magellan, and round Cape Horn. On these different coasts of America, the currents are generally pretty strong; but 20, 30, and 50 leagues off the coast, they are scarcely discernible. At Barbadoes there is very little current.

In the East Indies, the NE monsoon, which blows from October to April, and the SW monsoon, which blows from April to October, have very considerable effects on the waters over which they respectively pass.

From the east coast of China, during the NE monsoon, the waters are impelled with considerable velocity, along the coasts of Tonquin, Cochinchina, across the Gulf of Siam, towards the Malacca peninsula; and from thence they pass through the different straits west from Borneo, into the Java Sea, and are again carried by the NW winds (which prevail during the period the NE monsoon continues in the China Sea) eastward. Hence the impracticability of making a passage during the NE monsoon up the China Sea, or one down the Java Sea during the same period; although a passage is to be made either way, by going out of the one sea into the other.

The SW monsoon has the same effects, but in a contrary direction: But it is to be observed, that at some distance from the respective shores just mentioned, the currents are weak and feeble, when compared with their force in shore, and in the different straits through which they pass.

From the west side of the great Asian Archipelago, and eastern side of the Bay of Bengal, the waters, during the NE monsoon, are forced round the island of Ceylon, across the Arabian sea, until turned to the SW by Cape Guardafui. From thence they follow the direction of the coast, and run with considerable rapidity towards the Cape of Good Hope, where they are again turned, by the westerly winds, eastward towards New Holland; but in this last track, their force is extremely weak, for it has been repeatedly observed, that after passing to the southward or eastward of the great bank of Agulhas, the currents are hardly perceptible; whereas a ship on the bank will be sometimes set 20, 40, and often 60 miles in the 24 hours to the SW, against a heavy gale of wind from that quarter.

On the coast of Chili and Peru, from 30° of south to 4° of north latitude, the constant southerly winds force a current along that coast: And off Cape St Francis, Cape Passao, Cape St Lawrence, and Cape Blanco, they are generally very strong; but 40 or 50 leagues from the shore they are extremely weak: At the Gallapagos islands, they are hardly perceptible. On the coasts of Peru and Mexico, the same thing is observed.

All the former extravagant hypotheses respecting the force and direction of the currents in the Atlantic Ocean, seem eclipsed by that of Humboldt.

In his Personal Narrative, p. 44. he observes, "In latitude 39° 50′ north, longitude 16° 10′ west from Paris, we began to feel the effects of the great current, which from the Azores directs itself towards the Straits of Gibraltar, and Canary Islands." Hence it would seem, that Humboldt considers the Straits of Gibraltar as too confined to admit the whole of this body of water which he supposes sets from the Azores, and, therefore, he is pleased to separate it in its progress, making one half run by the Canary islands, whilst the other half enters the Straits of Gibraltar, to supply, I suppose, (though he does not say so,) the evaporation in the Mediterranean. He continues, "comparing the place deduced by the timekeeper with the pilot's reckoning, I was able to discover the smallest variation in the direction and velocity of the currents; and from 37° to 30° of latitude, I found a current from 18 to 26 miles in the 24 hours to the east." Now, without attempting to derogate from the universally recognised abilities of this celebrated philosopher, I am inclined to suspect, that had he been aware the local attraction of his ship acted on the magnetic needle directing his course, (which must have been about west,) he would not have considered this 18 or 20 miles error in the reckoning as being entirely the effect of currents. In prosecuting this train of reasoning, Humboldt makes the following curious remarks.

" We have just seen, that between the parallels of 11 and 43 degrees, the waters of the Atlantic are drawn on by the currents in a continual whirlpool. Supposing a molecule of water returns to the same place from which it departed, we can estimate, from our present knowledge of the swiftness of currents, that this circuit of 3800 leagues is not terminated in less than two years and ten months. A boat which may be supposed to receive no impulse from the winds, would require 13 months from the Canary Islands to reach the coast of Caraccas, 10 months to make the tour of Mexico and reach Tortoise Shoal opposite the port of the Havannah, while 40 or 50 days might be sufficient to carry it from the Straits of Florida to the banks of Newfoundland.

"It would be difficult to fix the rapidity of the retrograde current from the banks of Newfoundland to the coast of Africa. Estimating the mean velocity of the waters at 7 or 8 miles in the 24 hours, we find 10 or 11 months for this last distance."

In the following table, I have calculated the probable true variation on shipboard to every point of the compass, by allowing for the proportional change in the variation, according to the change in the ship's head. The standard variation used, is that which I obtained at St Agnes' light-house and St Mary's Castle; at the former of these places, it amounted to 27° 16′, at the latter 27° 31′, the mean 27° 23′ 30″ west. The change in the variation is taken at its maximum, or 10°; for with the ship's head at west, the variation amounts to 32° 23′; at east to only 22° 23′. When the head is north, or south, the variation is the same; and, consequently, the standard variation 27° 23′ must be used when the head is on either of these directions.

The space to which this table may perhaps be applicable, may extend from the Downs to Newfoundland, and to the 45° or 40° of north latitude.

By using the tabular variations given below, it is presumed the navigator, though deprived of observations, may put considerably more confidence in his dead reckoning; which, if the elements of the calculations are ascertained with due care, ought to come very near the truth. One thing is certain, that any navigator who has a good chronometer, and who is in the practice of making lunar observations, can never be led into any error by trying this method, and may easily satisfy himself of its truth. No person, indeed, can for a moment doubt the existence of local attractions, who has ever set an object by compass three or four miles off, and observed its bearing, when the ship's head was put on opposite points.

I must, however, remark, that I never had an opportunity of making any experiments of this kind on board merchant vessels; although I think it extremely probable, that a change of the variation of the same kind will, to a certain extent, take place in them; and this change will in all probability be much influenced by the nature of the cargo.

I may be allowed to add, that the paternal government of a country, so deeply interested in the perfection of navigation as Great Britain, will not certainly allow this most important subject to be long encompassed with either doubt or uncertainty. The employment of a few scientific men in making observations, and a very small expence, would suffice to remove both, and would, by so doing, essentially improve the science.

TABLE, *exhibiting the Degrees and Minutes to every Point of the Compass, with the Variation corrected for change in position of Ship's Head.*

Points of the Compass.		Degrees and Minutes to every point of the Compass.		Change of Variation with change of Ship's Head.			Supposed true Variation.			Variation corrected for change of Ship's Head.		
		°	′	°	′	″	°	′	″	°	′	″
South	North	0	0	0	0	0	27	23	0	27	23	0
S*b*W	N*b*W	11	15	0	37	30+				28	0	30
SSW	NNW	22	30	1	15	0+				28	38	0
SW*b*S	NW*b*N	33	45	1	52	30+				29	15	30
SW	NW	45	0	2	30	0+				29	53	0
SW*b*W	NW*b*W	56	15	3	7	30+				30	30	30
WSW	WNW	67	30	3	45	0+				31	8	0
W*b*S	W*b*N	78	45	4	22	30+				31	45	30
West	West	90	0	5	0	0+				32	23	0
South	North	0	0	0	0	0	27	23	0	27	23	0
S*b*E	N*b*E	11	15	0	37	30—				26	45	30
SSE	NNE	22	30	1	15	0—				26	8	0
SE*b*S	NE*b*N	33	45	1	52	30—				25	30	30
SE	NE	45	0	2	30	0—				24	53	0
SE*b*E	NE*b*E	56	15	3	7	30—				24	15	30
ESE	ENE	67	30	3	45	0—				23	38	0
E*b*S	E*b*N	78	45	4	22	30—				23	0	30
East	East	90	0	5	0	0—				23	33	0

On examining the variation found in the German Ocean it appears, that in no part is it so great as in the English Channel; and this quantity diminishes considerably, east from the meridian of Greenwich, on approaching the pole; but increases with the west longitude.

In Lat. 52° 31′, Long. 16′ west, Captain Phipps only found 20° 47′ west variation. Off Shetland, he found 20° 53′; and 23° 46′; and in Lat. 74° 25′, Long. 9° 18′ east, only 7° 47′; but twenty miles further south, and thirty-eight miles further east, he found 17° 9′ west variation.[1]

In Lat. 53° 38′, Long. 2° 22′ east, with the head NW, I found 24° 49′ westerly variation. In nearly the same Long. and fifty-six miles further north, with the head NW *b* N, the variation was observed 26° 18′. Off Shetland, with the head N *b* W, variation 27° 40′; two degrees further east, head N *b* E, 24° 4′; and fifty miles further east, with head NE, only 20° 40′ was observed.

In Lat. 73° 59′, Long. 29° 55′ east, with head NE *b* N, only 4° 55′ was observed; and almost in the same place, with head WSW, the variation amounted to 11° 20′ west. Close in with Lamb-head, Orkneys, with the head ESE, 20° 15′ variation was observed; and immediately after, with the head W *b* S, it amounted to 30° 40′.[1]

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[1] Phipps' Voyage towards the North Pole.

These observations made in 1814, compared with those made by Phipps in 1773, shew that the variation, during that interval, has increased up to the 70th or 75th degree of north latitude, by about 6° or 7°; and perhaps we may conclude, that the present correct variation is not less than 25° west.

Wishing if possible to have the exact quantity of variation more accurately ascertained, that it might be employed as a standard for deducing the *change* in the variation to be used in the German Ocean, similar to that which we have given for the English Channel, I made some hundreds of observations at different stations in the vicinity of Edinburgh. However, from the difference in the results found at the different places of observation, produced, perhaps, by local causes, it is difficult to pronounce which of them comes nearest the truth. The following are the different results:

At Edinburgh observatory, the mean result of 120 observations, gave the variation 27° 50′ 10″ west.

In Granger's Park, close to the West Church

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[1] Sybille's Table of Variations.

Charity House, the mean of 30 observations gave the variation 27° 36′ 2″.

In Major Alves's garden, situated close to the south side of the castle drawbridge, the mean of forty observations gave 27° 41′ 35″ west; the mean of the whole 27° 42½′. I however consider this variation two or three degrees greater than the variation at present existing in the middle of the German Ocean, and therefore I shall assume 25° as the mean variation in the subsequent calculations.

But although the actual variation may not be quite so great in the North Sea, as that found in the Channel of England, and at Edinburgh; the error in a ship's reckoning produced by the change of the variation depending on the change of the course, is nevertheless nearly the same.

On examining the different observations on the variation made by Captain Phipps, in his voyage towards the north pole, in 1773, differences to as great an extent, are every where observable, which can only be accounted for by the local attraction of the Racehorse. "We made," says Captain Phipps, "several observations, which we found, by those taken at seven in the afternoon, to be 17° 9′ west; by others, at three in the afternoon, only 7° 47′ west. I could not account for this very sudden and extraordinary decrease, as there were several different observations both in the morning and evening, which agreed perfectly with each other, without any apparent cause which could produce an error affecting all the observations of either set." Again, page 32, "I could not account from any apparent cause for the great change in the variation: The weather was fine, the water smooth, and every precaution we could think of to make the observations accurate."[1]

This difference in the variation on board the Racehorse, was no doubt the effect of local attraction; and the ship's head must have been on opposite points of the compass, or nearly so, when these different observations were made.

These differences must have produced errors in the dead reckoning; and accordingly Captain Phipps states, that the reckoning differed 36 miles from the observation, which he attributed to the defects of the log-line; though he sometimes alludes to errors in the dead reckoning, without assigning any particular cause.

When in the Greenland seas in 1814, I boarded a number of ships employed in the whale-fishery, whose masters all agreed in maintaining, that they experienced strong south-east currents on their return home, and were often confounded at making the coast of Norway, when they expected to make that of Shetland. Now, I have no hesitation in saying, that if the same difference in the variation is to be found on board a Greenland ship, as that which was found to exist on board the Sybille and Princess Carolina, the idea of a *strong* south-east current is unfounded; and is merely resorted to, to account for the error in the dead reckoning arising from not allowing a sufficiency of westerly variation in running from the ice to the south-west. A degree of longitude is soon lost or gained in those high latitudes; and the error must increase in running to the south-west, if proper allowance be not made.

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[1] See Table of Variations.

The Princess Carolina, as well as Sybille, experienced the same currents the masters of the Greenland ships supposed to exist; for when we made Shetland, by Arnold's chronometer No. 1981. to a mile, our dead reckonings were nearly 6° to the westward in both ships; and when we made the North Cape, by the same chronometer, (which was under my own care,) the longitude in both ships, by account, was 4° to the westward also.[1] The one error was occasioned by not allowing a sufficiency of westerly variation in running to the south-west, and the other by allowing too much in running to the north-east.

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[1] See Chart.

Being extremely anxious to ascertain the exact change of the variation on board the Ramillies, at anchor in Leith roads, with the permission of Captain Boys, and the ready assistance of Mr Borthwick, I made several observations, the result of which are inserted in the following Table.

I regret they are not more numerous; for I intended to make a series on every point of the compass; but as I did not belong to the ship, and could not, without much inconvenience, always attend her when swinging with the tide, I was obliged to limit the number. However, a sufficient number were made, to prove that the change of variation is fully as great on board ship in Leith Roads, and consequently in the North Sea, as in the English Channel; and that it coincides with that which I formerly found in the Sybille.[1]

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[1] The method I took was this. As the Ramillies was moored with her anchors in a north and south direction, her position, as to place, could not be altered much more than her own length, consequently could have little effect on the bearings of Lord Nelson's Monument, distant fully three miles. With my own azimuth compass placed in a stand at the binnacle, I carefully set the Monument in one day when the head was *eastward*, and in another when it was *westward*, and also when the ship's head was on the intermediate points of the compass, as exhibited in the Table.

Observations made on board his Majesty's ship Ramillies, in Leith Roads, for ascertaining the difference in the Bearings of Lord Nelson's Monument, when the ship's head was on different points of the compass.

Time.	Ship's head.	Bearings of Lord Nelson's Monument.	Difference in the Bearings.	By whom observed.	Place of the Ship where the observations were made.
1816		° ′			
Oct. 3	WSW	S24 30W		Mr Bain.	Taken close on the fore part of the poop, just over the wheel.
—	W *b* N	S24 50W		—	
—	W *b* N	S24 50W		—	
—	WNW	S25 5W		—	
—	NW *b* W	S26 35W	9 20	—	Taken at binnacle.
—	NW *b* W	S26 30W		—	Ditto.
4	E *b* S	S17 20W		Mr Gilson[*]	Ditto.
—	E *b* S	S17 20W		—	Ditto.
—	E	S17 15W		—	Ditto.
5	E	S17 15W		—	Ditto.
—	E½N	S17 15W		Mr Bain.	Ditto.
—	ESE	S17 25W		—	Ditto.
—	ESE	S17 25W		—	Ditto.
11	E *b* S	S17 20W		—	Ditto.
—	E *b* S	S17 20W	4 30	Mr Gilson	Ditto.
—	SSW	S21 50W		—	Ditto.
12	NW	S25 30W	9 10	Mr Bain.	Ditto.
—	NW *b* W	S26 10W		—	Ditto.
—	WNW	S26 30W		—	Ditto.
14	ESE	S17 20W		—	Ditto.
—	ESE	S17 20W		—	Ditto.
16	ESE	S17 20W		—	Ditto.

We have already seen, that in the English Channel, the error in the dead reckoning caused by the change in the variation, will, if not attended to, be productive of the most alarming consequences; and the same effects will follow from the same cause, if this change is not taken into account by ships navigating the German Ocean.

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[*] A young man of the most distinguished talents and acquirements.

The many fatal catastrophes that happened on the shores bounding the German Ocean, during the late war, are still fresh in our memories; and while we lament the loss of our gallant countrymen, we ought to endeavour to prevent or guard against such calamities in future.

We do not mean to insinuate, that the misfortunes to which we have alluded, are *wholly* to be ascribed to the masters not attending to the change in the variation. Innumerable circumstances conspire to produce shipwrecks independent of variation altogether; but it must be confessed, that there are cases where a ship may be so situated, that the not attending to the changes in the variation must be pregnant with the most fatal consequences.

For instance, a ship from the Baltic bound to Yarmouth, after taking her departure from the Scaw, will probably steer a direct course, as is supposed, S 70° W. by compass; which is, by allowing 25° of westerly variation, S 45° W. corrected. At noon next day, the ship has run half the distance, that is, 214 miles, and ought to be in latitude 55° 11′, and longitude 6° 23′; but by observation, the latitude is found to be 55° 0′, and the longitude 6° 40′; a difference of 11 miles in the latitude to the south, and 17 miles in the longitude to the east of the reckoning. This difference is immediately supposed to have been caused by south-east currents, and the course is altered more to the west, to guard against the like error in future; but when the land is made, the same error is continually found in the reckoning.

But what would have been the consequence, had the weather been such as to have precluded ascertaining the true position of the ship by observation? When it was expected to have seen Cromer, the ship would have been 20 miles to the south, and 36 miles to the east of it.

In this case, it has been supposed that the ship had a fair wind all the passage; but we may also suppose, that after she had got round the *Scaw*, the wind came round to the NW, and that she still continued standing on, though hardly laying her course. Thus circumstanced, with a short chop of a sea, after standing on for some time, she will not be able to clear the coast on either tack, and should a gale come on from by the change in the variation, will, if not attended to, be productive of the most alarming consequences; and the same effects will follow from the same cause, if this change is not taken into account by ships navigating the German Ocean.

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A ship bound from Yarmouth to the Baltic, will just experience the same error in the dead reckoning, as in coming to Yarmouth from the Scaw; and so very sensible are the more experienced North Sea pilots of this difference, that experience has taught them, though ignorant of its cause, to make allowances accordingly.

Suppose the Ramillies were ordered from Leith to the Baltic, it is evident, if the change of variation found on board that ship, as expressed in the Table, were not attended to, it would be impossible her dead reckoning could be near the truth.

From the island of May to the Naze of Norway, the direct course is nearly N 70 E, distance about 346 miles; and gives 118 miles difference of latitude, and 594 miles difference of longitude; and by allowing 25° of westerly variation, the course steered by compass is E 5° S. Now with the Ramillies' head in this direction, only 20° 30′ variation will be found, which makes a difference of 27 miles of latitude to the south, and 18 of longitude to the east; that is, the ship is thus much to the south-east of her reckoning.

The same error in the reckoning will equally hold good, were the Ramillies returning to Leith from the Naze of Norway.

In submitting the following Table of the Variation corrected for local attraction, to every point of the compass in the German Ocean; I am aware that there are places in it where 25° may be rather too much, and in others too little. For instance, on the east side of the Orkney and Shetland islands, close in shore, the variation is considerably more than on the coast of Norway; and perhaps the same thing may hold good on the east coasts of Scotland, and England, and those of Holland. But I apprehend these local influences extend but to a very little distance from their respective shores.

It would, indeed, be extremely desirable for the further improvement of science and navigation, to ascertain accurately how much the magnetic needle is influenced at different distances by the promontories and islands bordering on the German Ocean and St George's Channel. And as this might be ascertained at a very inconsiderable expence, let us hope that the accomplishment of so very laudable an undertaking is not far distant.

Table exhibiting the Degrees and Minutes to every point of the Compass, with the Variation corrected for change in Position of Ship's head.

Points of the Compass.		Degrees and Minutes to every point of the Compass.		Change of Variation with Change of Ship's head.			Supposed True Variation in the North Sea.			Variation corrected for Change of Ship's head.		
		°	′	°	′	″	°	′	″	°	′	″
S	N	0	0	0	0	0	25	0	0	25	0	0
S *b* W	N *b* W	11	15	0	37	30+				25	37	30
SSW	NNW	22	30	1	15	0+				26	15	0
SW *b* S	NW *b* N	33	45	1	52	30+				26	52	30
SW	NW	45	0	2	30	0+				27	30	0
SW *b* W	NW *b* W	56	15	3	7	30+				28	7	30
WSW	WNW	67	30	3	45	0+				28	45	0
W *b* S	W *b* N	78	45	4	22	30+				29	22	30
W	W	90	0	5	0	0+				30	0	0
S	N	0	0	0	0	0	25	0	0	25	0	0
S *b* E	N *b* E	11	45	0	37	30—				24	22	30
SSE	NNE	22	30	1	15	0—				23	45	0
SE *b* S	NE *b* N	33	45	1	52	30—				23	7	30
SE	NE	45	0	2	30	0—				22	30	30
SE *b* E	NE *b* E	56	15	3	7	30—				21	52	30
ESE	ENE	67	30	3	45	0—				21	15	0
E *b* S	E *b* N	78	45	4	22	30—				20	37	30
E	E	90	0	5	0	0—				20	0	0

SECTION FIFTH.

Captain Flinders' Rule for ascertaining the amount of the Changes in the Variation—Remarks on that Rule—Miscellaneous Observations.

Having already remarked, that we are indebted to Captain Flinders for the discovery of the causes of the changes in the variation on shipboard: We shall now give his rule for ascertaining the amount of this change, according to the point of the compass to which the ship's head is directed, on which we shall have to offer some remarks.

Soon after Captain Flinders left England on his last voyage, he observed that the change in the variation was closely connected with the results given by the dipping needle; and that as the dip increased or diminished, so did the change of the variation.

Speaking of this subject, he observes, "But although the errors (changes of the variation) were always the same way in the same hemisphere, when the head was at west, and when it was east they were always the contrary, yet the quantities varied with the situation of the ship, being greater in high, and less in low latitudes; and yet they did not increase and diminish in proportion to the latitude. After much examination and comparison of observations, and some thinking on the subject, I found that the errors had a close connection with the *dip of the needle*. When the north end of the needle had dipped, it was the north point of the compass which had been attracted by the iron in the ship; and as that dip diminished, so had the attraction, until, at the magnetic equator, where the dipping-needle stands horizontal, there seemed to be no attraction. After passing some distance into the southern hemisphere, and the south end of the needle dipped, our observations again showed errors in the compass; but the west variation was now too great when the ship's head was eastward. These errors increased as the dip augmented; and in Bass' Straits, where the south dip is nearly as great as the north dip in the English Channel, the attraction produced almost as much error as when we left England, but it was of an opposite nature; and I therefore considered the connection between them to be so far certain, as to make the dip our *datum* in reducing the observed to the true variation."

"Another point of equal importance remained to be known: the compass stood right in both hemispheres when the ship's head was at north or south, and erred most on one side when the head was west, and on the other when it was east; but what was the proportion of error at the intermediate points, between the magnetic meridian and east and west? Unfortunately, the direction of the ship's head when observations were taken, had not been particularly marked in the first part of the voyage, nor always in the latter part; and in gathering it from the courses steered when under way, and from the direction of the winds and tides when at anchor, there was often a good deal of uncertainty; but it was evident, that the quantity of error increased as the angle between the ship's head and the magnetic meridian became greater. After some consideration, it appeared to me, that the magnetism of the earth, and the attraction forward in the ship, must act upon the needle in the nature of a compound force; and that the errors produced by the attraction should be proportionate to the *sines* of the *angles* between the ship's head and the magnetic meridian. I tried this upon many observations where the direction of the head was least doubtful, and found the difference to correspond as nearly as could be expected, and sometimes exactly: it therefore seemed probable, that the *error produced at any* *direction of the ship's head, would be to the error at east or west, at the same dip, as the sine of the angle between the ship's head and the magnetic meridian, was to the sine of eight points,* or radius. According to this, when the error was ascertained at any given direction, more especially at east or west where it was greatest, it might be found at any direction required, by inspection in the Traverse Table."

After Captain Flinders' arrival in England, he made application to the Lords Commissioners of the Admiralty to have experiments tried on board some of his Majesty's ships, that the observations he had made during his voyage might be verified. A series of observations were accordingly made on board five different ships at Sheerness and Portsmouth, which fully established the accuracy of his former conclusions. After being satisfied in this particular, he considers the law before deduced from analogy as certain. "I employed it to find a standard correction for all my observations in the Investigator. For this purpose, a selection of them was made where the ship's head was in the most opposite points, and farthest from the meridiam, and where the true variation could be ascertained within a small quantity; the difference between the observed and true variations gave the errors, and when the head had not been at east or west, they were proportioned to eight points, or radius, by the sines of the angles. These observations were collected into Tables, one for the north, and another for the southern magnetic hemisphere, and classed according to the dips of the needle; and the error for eight points at each dip being reduced to parts of the dip, a medium of the whole was taken, and considered to be the standard radius, applicable to all situations."

The following are the Tables alluded to, to which I have added his examples for finding the true variation.

Observations taken at different Dips of the Needle in the Northern magnetic Hemisphere, from which are deduced the Errors of Variation at the Investigator's Binnacle, when the Ship's head was at East or West. By Captain Flinders.

Time.	Lat. North.	Long. West.	Azim. or Ampl.	Ship's Head.	Variation observed West.	Variation supposed true.	Errors of observation.	Errors at eight points.	Dip N.	Remarks.
1801. July 20. P. M.	49° 50′ 49 48	3° 52′ 4 2	Azim. Ampl.	W —	29° 34′ 29 30	25° 40′ —	3° 54′ — 3 50 —	3° 52′	72	Off the Start.
Aug. 29. A. M. Sept. 5. A. M.	5 38 2 21	16 50 14 15	Azim.	SE*b*S WSW	12 18 14 54	13 15 13 40	0 57 + 1 14 —	1 43 1 20	32 26	Off the African coast.

At dip 72°, error for 8 points 3° 52′, or in parts of the dip . .0537
. . 29 . . . . 1 31½ 0526

Mean error for eight points in parts of the dip 0531

Observations taken at different Dips of the Needle in the Southern Magnetic Hemisphere, from which are deduced the Errors of Variation at the Investigator's Binnacle, when the Ship's head was at East or West.

Time.	Lat. South.	Long. East.	Azim. or Ampl.	Ship's head.	Variation observed.	Variation supposed true.	Errors of observation.	Errors at eight points.	Dip S.	Remarks.
1802. Apr. 10. A.M.	35° 38′	139° 3′	Ampl.	W *b* S	5° 11′ E	1° 41′ E	3° 30′ +	3° 24′	66	Encounter Bay.
P.M.	35 49	139 12	Azim.	SE	0 50 W	—	2 31 —			
——12. P.M.	36 42	139 50	—	SSE½E	1 25 E	3 0	1 35 —			
——15. A.M.	37 30	139 40	Ampl.	S	4 8	—				
——16. A.M.	37 50	139 41	—	SE *b* S	2 39	4 8		3 23	67	Off Cape Buffon.
	37 56	139 41	Azim.	SSE	2 2	—				
P.M.	37 55	139 48	—	NE	2 2	—	1 54 —			
——22. A.M.	39 38	144 40	—	WSW	11 52	8 30	3 22 +			
——24. A.M.	39 38	144 1	—	S	7 59	—		3 26	68	Bass' Straits.
——25. P.M.	38 36	144 20	—	NE *b* E½E	3 41	7 30	2 16 —			
——26. A.M.	38 38	144 30	Ampl.	NNE½E	6 48	—				
							Means	3 28	67	

Table continued.

Time.	Lat. South.	Long. East.	Azim. or Ampl.	Ship's head.	Variation observed.	Variation supposed true.	Errors of observation.	Errors at eight points.	Dip S.	Remarks.
1802. Jan. 16. A.M.	34° 5′	123° 9′	Azim.	WSW	0° 54′ W	3° 30′ W	2° 36′ +	2° 45′	64	At anchor in Goose J. Bay.
1803. May 20. P.M.	34 4	123 10	—	E	6 10	—	2 40 —			
1802. Feb. 15. P.M.	34 5	135 9	—	SE *b* E	1 33	1 11½ E	2 44½ —	3 18	—	Off Pt. Drummond.
——	34 6	135 9	Ampl.	SW *b* W	3 56 E	—	2 44½ +			
Mar. 16. P.M	34 7	137 19	—	SW *b* S	4 38	2 50	1 48 +	3 18	—	Off Port Pearce.
——17. A.M.	34 16	137 16	Azim.	E *b* N	0 10 W	—	3 0 —			
——17. P.M.	34 22	137 21	—	SE	0 35	2 0	2 35 —			
——18. P.M.	34 42	137 14	Ampl.	SSW	3 15 E	—	1 15 +			
——28. P.M.	34 36	138 18	—	S *b* W	5 22					
——29. A.M.	—	—	Azim.	SE	2 27	4 45	2 18 —	3 15	—	At anchor.
							Means	3 9	64	
1802. Jan. 19. P.M.	32 40	125 25	Azim.	E *b* N	7 15 W	4 30	2 45 —	2 48	62	Off S. Coast.
——20. P.M.	32 30	125 40	—	S	4 26	—	—			
——21. P.M.	32 32	125 54	—	NE	6 13	4 15	1 58 —			
——22. P.M.	32 24	126 23	Ampl.	S *b* E	4 18	—	—			
——24. A.M	32 7	128 1	Azim.	N *b* E	6 4	3 0	3 4 —	3 8	—	
——25. P.M.	32 17	128 2	—	S *b* E	3 8					
——31. A.M.	32 15	132 39	—	N *b* E	2 49	0 0	2 49 —	2 52	—	Nuyt's Archip.
Feb. 2. A.M	32 23	132 56	—	S½W	0 19 E					
							Means	2 56	62	

Table continued.

Time.	Lat. South.	Long. East.	Azim. or Ampl.	Ship's head.	Variation observed.	Variation supposed true.	Errors of observation.	Errors at eight points.	Dip S.	Remarks.
1802. July 28. A.M.	25° 0′	153° 23′	Ampl.	NW *b* N	9° 30′ E	8° 12′ E	1° 27′ +	2° 36′	53½	Off Indian Head.
——29. A.M.	24 43	153 27	—	SE½S	6 33	—	1 39 −			
Sept. 3. A.M.	23 33	150 16	Azim.	SE *b* E	6 31	8 45	2 14 −	2 41	50½	Anchor at Shoal Water Bay.
—	—	—	—	WNW	11 15	—	2 30 +			Do. ship swung.
							Means	2 39	52	
1802. Nov. 21. P.M.	17 7	139 43	Ampl.	ENE	2 38 E	4 30	2 2 −	2 12	44½	
——22. P.M.	—	—	—	Northerly	4 30	—	—	—		
Dec. 8. P.M.	16 41	138 27	—	NW	4 10	2 40	1 30 +	2 7	43½	
——10. P.M.	16 16	137 57	—	W *b* N	4 45	—	2 5 +			
1803. Jan. 2. P.M.	14 19	136 1	—	E *b* S	0 43	—	1 57 −	2 4	41½	
—— 6. P.M.	14 19	136 23	—	SE	1 9	—	1 31 −			
							Means	2 8	43	

At dip 67°,	error for 8 points	3° 28′,	or in parts of the dip	.0517
64	— — —	3 9	— — —	.0492
62	— — —	2 56	— — —	.0473
52	— — —	2 39	— — —	.0510
43	— — —	2 8	— — —	.0496
Mean error for eight points in parts of the dip . . .				.0498

The medium error for eight points deviation of the Investigator's head on either side of the magnetic meridian was therefore very nearly one-twentieth part of the dip; and (.0498 called) .05, the decimal expression of it, is the common multiplier to the dip for obtaining the radius of error at any situation in the southern hemisphere; as the decimal (.0531 called) .053 is the common multiplier from England to the magnetic equator.

In correcting the variations to what is presumed they would have been if observed with the ship's head in the magnetic meridian, the following plan was used. With the dip of the needle as near as it could be known, and the common multiplier, the radius, or error for eight points, was obtained, with this, taken as a distance, and the direction of the ship's head as a course, the correction was found in the departure column of the Traverse Table; and being applied to the observed variation, either to the right or left, according as the dip was north or south, and the head on the west side of the meridian, it gave the true variation.

Example. The dip being 66° south, and the ship's head W *b* S, the variation was observed to be 5° 11′ east; required the true variation?

Dip 66° × .05 = error for eight points 3° 30′ = (3° 18′ =) 198′. Course 7 points, and distance 198′= departure 194′, or 3° 14′ correction. Then, as in south dip the south end of the needle was drawn forward; or in this case to the west, and the north end to the east, the east variation observed was too great, and must be reduced 3° 14′; and 5° 11′ observed — 3° 14′ correction = 1° 57′ east, the true variation.

Example. Suppose that with the ship's head WSW, the variation was observed to be 29° 12′ west in the English Channel, where the dip is 72° north, and I wished to know what variation is to be allowed upon a set of bearings taken when the head was at NE½E.

1*st.* To find the true variation.

Dip 72 × .053 = error for 8 points 3° .816 = (3° 49′ =) 229′.

Course 6 points, distance 229′=departure 212′, or 3° 32′ correction.

Being in north dip, the north end of the needle was drawn forward, that is, westward in this case, and the west variation observed was too great; therefore 29° 12′ observed — 3° 32′ correction = 25° 40′, the true west variation.

2d. To find from thence what is to be allowed with the head at NE½E.

Course 4½ points; distance 229 = departure 177′, or 2° 57′ correction.

With the head at NE½E, the north end of the needle at the binnacle would be drawn eastward; and the west variation be less than the true; therefore, true variation 25° 40′ — 2° 57′ = 22° 43′ to be allowed, deduced from 29° 12′ observed.

On considering the rule here assigned for ascertaining the change in the variation caused by a change in the direction of the ship's head with attention, it appears that Captain Flinders considers the change as wholly produced by the magnetic force which influences the dipping needle; and that the force by which the compass needle is affected, (for we have already shewn in Section III. that the compass and dipping needles are apparently influenced by different systems of magnetic attractions,) has no connection with the local attraction in the ship, by which the change in the variation is produced; and that, therefore, it matters not how great or how small the variation of itself may be, as that circumstance cannot affect this supposed general cause. If this be really the case, then, indeed, the principles on which his rule are founded must be correct, and applicable to all situations. But if the change in the variation produced by the change in the direction of the ship's head depends, in the smallest degree, on the magnetic force which influences the common compass needle, this rule must often be very erroneous.

By referring to the Tables of Dip it will be observed, that when Captain Phipps found the dip at Spitzbergen to be 82°, there was only 12° or 16° of variation; whereas in England, the dip was only 72°, with 25° of variation; at the Cape of Good Hope, the dip was only 45° 25′, whilst the variation amounted to 25°; at Fayal, the dip was 71°, and the variation 22°; at the Island of Ascension, the dip was only 8° 57¼′, whilst the variation amounted to 10° 52½′. On the magnetic equator, where of course there is no dip, 5° 30′ variation was found. In Lat. 20½° south, Long. 31½° west from Paris, there was no variation, whilst the dip was 14°. From Macao to Kamtschatka, the variation is scarcely sensible, but the dip runs from 11° to 47°, 50°, 56°, 58°, 64°, and even to 71°. Many more instances could easily be given of the discordance between the dip and the variation, but those here mentioned are sufficient.

In trying any of the above examples by Captain Flinders' rule, it will be observed, that the

change, or error, in the variation is as great where there is no variation, as it is where it amounts to 22° and 25′.

Ex. 1. At Spitzbergen, with the head west, dip 82° N. observed variation 16° west, required the true variation?

Dip 82° N. × .053 = error for eight points 4° 346 (4° 27′ =) 267′. Variation observed 16° 0′ — 4° 27′ = 11° 33′ true variation.

Ex. 2. On the coast of England, with the head west, dip 72° N, observed variation 25° west, required the true variation.

Dip 72° N. × .053 = error for eight points 3 816 (3° 49′ =) 229. Variation observed 25 — 3° 49′ = 21° 11′ true variation.

Ex. 3. At the Cape of Good Hope, with the head west, dip 45° S, observed variation 25 west, required the true variation.

Dip 45° S. × .05 = error for eight points 2° 25′ (2° 13 =) 135. Variation observed 25 + 2° 13′ = 27° 13′ true variation.

Ex. 4. At Fayal, with the head west, dip 71 N, observed variation 22° west, required the true variation.

Dip 71° N. × .053 = error for eight points 3° .763 (3° 23′ =) 203. Variation 22° — 3° 23′ = 18° 37′ true variation.

Ex. 5. At the Island of Ascension, with the

head west, dip 9 S. observed variation 10 52½ west; required the true variation.

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Dip 14° S. .05 = error for eight points 0° .70 (0° 42′ =) 0° 42′. Variation 0° 0′ + 0° 42′ west.

Ex. 8. At Kamtschatka, head west, dip 71° N. observed variation 0° 0′; required the true variation.

Dip 71° N. × .053 = error for eight points 3° .763 (3° 23′ =) 203′. Variation 0° 0′ — 3° 23′ = 3° 23′ east, true variation.

In the first of these examples it will be observed, that in passing from England to Spitzbergen, the magnetic force by which the north end of the dipping needle is influenced increased 10°; whereas the power by which the compass needle is made to deflect from the true meridian dimi-

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In the first of these examples it will be observed, that in passing from England to Spitzbergen, the magnetic force by which the north end of the dipping needle is influenced increased 10°; whereas the power by which the compass needle is made to deflect from the true meridian dimi-

nished 10°; but by Captain Flinders' rule, the change of variation would be 1° 16′ greater at Spitzbergen than at England.

At the Cape of Good Hope, example third, the magnetic power influencing the dipping needle is 27° less than at England; but the compass needle is affected by the same degree of magnetic strength at both places, although, by the rule, a difference of 2° 52′ is found in the change of variation.

At Fayal, example fourth, situated about an equal distance north from the equator as the Cape of Good Hope is south from it, the magnetic strength influencing the dipping needle is 26° more than at the Cape, and only one less than at England, although the force affecting the compass needle at all the three places is nearly equal.

At the Isle Ascension, example fifth, the magnetic power affecting the dipping needle is 73° less than at Spitzbergen, although the compass needle, at both places, is nearly influenced by the same power; but the change of variation produced, by the rule, is 7° 56′ less at the former than at the latter of these places.

On the magnetic equator, example sixth, where the dipping needle is not influenced, the force affecting the compass needle is strong enough to produce 5° 30′ variation; but, by the rule, there can be no change in the variation, put the ship's head on any meridian you please.

In example seventh, the magnetic power over the dipping needle is equal to 14°, but that which influences the compass needle is imperceptible, and consequently it must point to the true poles of the world; by the rule, however, 1° 24′ change of variation is obtained.

At Kamtschatka, or on that coast, in example eighth, there is no variation, or no magnetic force causing the compass needle to diverge from the true meridian; but it is not so with the dipping needle, which is influenced 71°; by the rule, however, the change of variation amounts to as much as at England and Fayal, where the magnetic force influencing the compass needle amounts to 25° and 22°.

From this view of the subject, it is presumed we may conclude, that if Captain Flinders' rule for finding the change of variation, depending on the change in the direction of the ship's head, is founded on correct principles, the magnetic force causing this change of variation, and that producing the ordinary variation itself, must be essentially different; and that the former must be identical with the magnetic force producing the dip.

We do not say this is not the case, nor that the results, as given in the above examples, may not correspond with the deductions of experience; but we think, that, if the magnetic force by which the variation of the compass is produced is so very feeble as to have no attractive power over the compass needle, the iron work in the ship will also lose most of its magnetism, and that the changes of variation do not depend wholly on the magnetic power influencing the dipping needle. But until an accurate series of observations shall determine this point, our suspicions, we confess, as to the inaccuracy of the rule, will not easily be removed. This is a point of much importance, inasmuch as, if the rule is really correct, any officer, with very little trouble, may always be able, in any part of the world, to ascertain the true variation to be allowed on the ship's course.

Let a ship, provided with good instruments, ascertain accurately the exact change of variation on each different course, in the English Channel or North Sea, then proceed to Archangel, where the variation is very inconsiderable, and after accurately ascertaining the changes there, proceed to Davis' Straits, where the variation is very considerable, and make the same observations. If these experiments shall coincide, the rule must be instituted on true principles; if not, it must be erroneous.

It may, however, be assumed, that in different ships, the local magnetic attraction will also be different; and it is extremely probable that a first rate of 120 guns will have more attraction than one of 74 guns, she more than a frigate, and a frigate more than a sloop of war; and I am led strongly to suspect, that the change in the variation found on board the Investigator, is by no means so great as that observed on board the Sybille and Ramillies. Captain Flinders only allows, as the change of variation, 7° 38′ in the Channel and North Sea; whereas in the Sybille and Ramillies, we observed from 9° to 10°. All ships of war have, besides their guns, a great quantity of pig-iron ballast, which, no doubt, contributes, jointly with the other iron-work in the ship, to produce a greater or less amount of local magnetic attraction. This remark may also apply to our East India ships.

The generality of merchant ships having neither guns nor pig-iron ballast, we should imagine, could not have so much local attraction as ships of war. But the case may be greatly reversed when loaded with iron,* and, perhaps, other cargoes in mass. * Tallow, it is asserted, exerts a very considerable attraction on the needle.

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* The following note is taken from a Morning Paper.—

Another circumstance of equal importance must also be taken into consideration before *any general rule* can be framed for finding the exact change of variation in any ship; and that is, the *situation of the binnacle.* Most ships differ in size and construction; and in all, the binnacle is placed as whim or caprice may suggest. Some tillers are short, others long; and it is often whimsical enough to observe where the wheel is placed. If the binnacle, we presume, was placed in the centre of the ship, the local attraction would always be equal when the cargoes were the same; but when it is removed from the centre towards either extremity, then undoubtedly a change must take place.

The position of the binnacle is therefore of the first importance, and must be ascertained before

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Caution to Navigators. A Captain of a ship, lately on her passage from Bristol to Milford Haven, was much surprised to find that the course he was steering by compass was at variance with the well-known land-marks of the coast he was traversing. Several compasses were tried, but not one could be found that pointed north by two or three points. It was surmised by one of the passengers, that as the ship was laden with iron, it might have an effect on the needle. The compasses were moved to another part of the ship, and the experiment fully confirmed the surmise.

* Clarke's Maritime Discovery, vol. i. App. pp. 254, 255.

we can determine how much the needle is influenced by local attraction, and before any rule can be applied to ascertain the change of variation. Captain Flinders was so thoroughly convinced of this, that, after ascertaining the correct change at the Investigator's binnacle, he put no dependence on amplitudes or azimuths taken at other stations of the ship. But in fact, whenever the observations made on the dipping needle are required for correcting the errors of variation caused by a change in the direction of the ship's head, they can be seldom resorted to. The observations hitherto made with this instrument have been confined to a few voyages of discovery; and from the delicacy of its construction, and extreme difficulty of management, we may assume, that without some improvement is made in it, its use can never become general.

The following easy and simple rules may, if observed, be of some service to navigators.

1*st*, Let the binnacle be permanently fixed: The bolts and nails all of copper.

2*d*, Let a place be made on the top of the binnacle for the azimuth compass to stand on: and all ships ought to be provided with this instrument.

3*d*, A man of war ready for sea, or a merchant ship when her cargo is all on board, ought to take every opportunity, before sailing, of setting, with the azimuth compass from the binnacle, some fixed object, the greater the distance the better, when the ship's head is at *east* and at *west*, and note the difference of the bearings carefully in *log-book*. Half this difference added to the variation, when observed with the ship's head at *east*, will give the true variation. But when the variation is observed when the ship's head is at *west*, half the difference must be subtracted from the observed variation to give the true variation. When the variation is observed with the head on any of the intermediate points between *north* and *east*, and *south* and *east*, add the proportion of half the difference to the observed variation, and it will give the true; but this proportion must be subtracted from the observed variation, when it is observed with the head on any of the intermediate points *west* from *north* or *south*.

To neglect such an easy operation, after knowing the consequences that may thence result, seems highly reprehensible; and where the lives and property of individuals often depend on the true course steered, no circumstance, however minute, ought to be neglected in making that as accurate as possible.

In the different channels of England, and in the North Sea, the weather is often such as to preclude every opportunity of accurately ascertaining the ship's true position; and in such cases the true course is the only element to be depended on. But if a ship, as we have already remarked, is making only an E *b* S course where it is supposed she is going *east;* or a west course when it is thought she is going W *b* N, how can the reckoning possibly fail in being very erroneous? The ship may often escape danger, from a variety of fortunate circumstances, which human wisdom could neither foresee nor foretel; but there are many situations in which a ship may be so placed, by not attending to this change, or error of variation, that shipwreck is inevitable.

Let insuring-offices and underwriters, who are the safeguards of the shipping interest, convince themselves of this truth: It is them who suffer, and therefore ought to be interested. If they would only send some experienced man on board a ship laden with iron, or perhaps other cargoes, and there make such observations as are here recommended, his report would, perhaps, account to them for the loss of many thousands, of which neither the *widow,* the *orphan,* the *mother,* nor the *father,* of the unhappy navigator shared one shilling.

No merchant would incur the expence of insuring his ship and property, were he certain no loss would take place during the voyage; and no insurance company would transact any policies, were they certain the risk was too great. Both are actuated by motives truly interested. The merchant insures to preserve; the insurer to accumulate. The one is guided by prudence, the other by speculation; and so far the transaction is just and commendable, and often terminates satisfactorily to both parties. But may it not happen, that when a ship-owner finds himself safely intrenched behind a policy of insurance, the vessel may not be properly provided? It has often come under my own observation, to see very valuable ships navigated by men of the grossest stupidity and ignorance, and manned by crews truly despicable. When such is the case, the fate of the ship, the lives of the navigators, and the property of individuals, are trusted almost to mere chance; and the insurer seldom knows what risks he runs. If the ship arrives safe, no inquiries are made. If lost, the true cause can seldom be discovered: There was an error in the reckoning, caused by strong currents—the ship was leaky—one head-land was mistaken for another—a gale came on, and the ship could not weather a certain shoal—a port was attempted to be made, but at the close of the day, she was obliged to haul her wind after getting on a lee-shore—at length she anchored and drove on shore. Such are a few of the common-places which ignorance and stupidity frequently assign as apologies for their own misconduct.

Every loss of this kind is a national loss; for, though the insurer suffers in the first instance, it nevertheless is felt by the whole community: the loss is equivalent to as much capital being thrown into the sea, and the nation is so much the poorer. Policies of insurance, for this very reason, ought to be agreed on with the greatest circumspection. The character of the ship, the length and risk of the voyage, the danger of fire, &c. ought not to be the only investigations of the insurer; his inquiries ought also to be directed towards the talents and skill of the person acting as captain. The insurer's stake in the safety of the voyage is deeper than either that of the merchant or shipowner; and, therefore, he ought to attend to his interests with the utmost attention.

May we not hope, that, after having shewn from incontrovertible evidence, to what dangers a ship is liable from not attending to the change of variation, this subject will also attract the attention of all classes connected with the shipping interests of the nation? It is one of vastly more importance than is generally imagined.

During the last war, no class of ships in the

British service suffered so many shipwrecks as those employed by the transport-board; and the mind sickens on recollecting the thousands of our gallant soldiers, who, after braving death in the field, found it awaiting them at sea.

To attempt to assign any particular cause as producing these losses, would be absurd. But we are certain, that no care or attention was wanting on the part of Government to render transports as safe and comfortable as human ingenuity could possibly devise: and probably these catastrophes may have been partially owing to the following circumstances.

Most of the ships in the transport service have originally been coalliers, belonging to the ports of Whitby, Scarborough, Shields, Sunderland, and Newcastle. The masters commanding those ships have been generally engaged in the same service, and understand the management of ships in that trade extremely well. This will not be thought surprising, when it is considered that they are trained from their infancy in the coal trade; and as a knowledge of the navigation between London and Newcastle can easily be acquired, without the aid of any liberal or extensive knowledge of the different branches of nautical education; it is not extraordinary that these captains, though extremely well fitted for their own trade, should be grossly ignorant when brought into a situation where routine and local experience are no longer of any assistance.

When coalliers are taken up by Government for the transport service, their masters are commonly continued in the command; and as long as they are attended by any of his Majesty's ships to convoy them from place to place, the service on which they are employed cannot well sustain any material inconvenience; although it must be acknowledged, that their disobedience to orders, their inattention to signals, and apparent ignorance of their meaning, are often the cause of much hinderance to the service in which they are employed. But when any accident occasions a separation from the convoy, and when they are left wholly to the resources of their own judgment to navigate the ship to the place of destination, there is reason to doubt they will often involve themselves in difficulties. This may be considered illiberal, but I am afraid experience will more than justify the supposition.

A sudden or unexpected embarkation of troops, stores, &c. and an immediate departure, often creates some disorder and confusion; and the ship may have proceeded some days on her voyage before any proper arrangement can take place. During this interval, and perhaps for the whole passage, the soldiers' muskets may be placed in chests, or otherwise, sufficiently near the compasses in the binnacle to affect them by their attraction. It is true, that when a number of ships are together, and under convoy of ships of war, no serious accident may happen; but should a separation take place, and the error in the compasses escape detection, an error of considerable magnitude must get into the reckoning; and as those ships seldom possess the means of correcting this error by chronometrical or lunar observations, the consequences must be sufficiently obvious, and extremely fatal.

FINIS.

ERRATA.

Page 25. line 12. from the top, for "80° 0′ Long." read "0° 0′ Long."

In Sybille's Table of Variation, observed in East Greenland, in 1814, Sept. 14th, in column of Remarks, for "both sides excellent," read "both sights excellent."